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Priority 6.2: Sustainable Surface Transport

INTEGRATED PROJECT

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CREAM

Research Activity 5: Integration concept for the Betuweroute

Deliverable DR 5.1: Documentation of integration concept of the Betuweroute, incl. presentation of maintenance concept

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Foreword

Research Activity 5 deal with the integration of the Betuweroute, a dedicated freight railway line between Rotterdam port and its (German) hinterland into the existing European rail freight network and more in particular into the CREAM corridor. This integration generates a long list of requirements and consequences for infrastructure management (availability, access and pricing), train scheduling (long-term and daily planning and cross-border) and maintenance (short- and long-term) of the Betuweroute [1]. Many of these requirements and consequences are also relevant for the national and international railway infrastructure connected with the Betuweroute. It is clear that innovation is necessary to improve the competitive edge of railways. However, innovations rendering other parts of the European railway network less interoperable or even outdated should be rejected.

This quite complex and wide-ranging document was prepared by OTB. OTB took over the projectleadership role form Keyrail (former BR-EM) in mid 2008.
Since then OTB and Keyrail have co-operated in order to prepare this document. Keyrail, RDE and KV provided written and oral information about their activities related with this new freight railway line.
The delay in the work for this workpackage is related with the complex and delayed start-up phase of this first commercially maintained freight railway line in Europe.

OTB has used the available information in the most appropriate way. In some cases required information was not available. As a result, some of the tasks could not completely be fulfilled, this is clearly marked in the text. It is common in any research project that not all assumed information is available or released by those owning it, including stakeholders with a clearly identifiable (economic) interest in a project.
With the presentation of this document, Research Activity 5.1 is finished.

[1] The TA mentions the name Betuweline. Section 3.2 explains the proper name Betuweroute.

Figure 1. Some photos of the new railway line

Source: http://www.kennis.betuweroute.nl/home/betuweroute/beeldarchief.

1. Introduction

1.1 Objectives

According to the Technical Annex (version 2008, p. 81, slightly adapted) the objective of RA 5.1 is to develop an innovative dedicated freight concept that integrates the Betuweroute into the operational network of the corridor. Such a concept includes a maintenance concept for high tech rail infrastructure.

1.2 Participants

Final partners in RA 5.1 were Keyrail, OTB, KV and RDE. When this workpackage was defined, RNL was the main operating partner. Later on, RNL was unable to fulfil the requirements and subsequently ended its involvement into the CREAM project. RDE replaced RNL, but RDE later on withdrew itself to a large extent from this workpackage. KV stepped in as a new partner following its decision to activate its 'sleeping' operational license in response to what it perceived as an inability of RDE to provide an acceptable service level.

Figure 2. Marshalling yard at Kijfhoek
Source: Edwards, 2007a.

2. Description of work

2.1 Introduction

This document deals with key implementation issues of the Betuweroute. Section 3 acts as a short introduction to this railway line.

The following tasks were foreseen for this workpackage:

- Technical-economical analysis of the operational prerequisites for an efficient integration of the Betuweroute in the European rail network (section 4);
- Development of an innovative infrastructure maintenance concept optimizing maintenance costs, safety and operational availability of the Betuweroute (section 5);
- Optimized train parameters on the Betuweroute: Describe the restraints currently imposed by the Betuweroute infrastructure for driving long freight trains (1.000 to 1.500m) and analyze the modifications needed for alleviating these limitation (section 6);
- Deduction of required equipment for the locomotives with respect to operation schemes and improved train parameters (section 7);
- Deduction and recommendation of additional short time measures, general framework for train path pricing under consideration of envisaged models for funding of additional equipment on locos by the EC (section 8);
- ERTMS (European Rail Traffic Management System) implementation strategy for this part of the corridor (section 9);
- Development of an implementation/action plan for future freight service and operation on the Betuweroute as basis for demonstration under consideration of the results of the MoU between the European railway associations and the EC for corridor A (Rotterdam to Genoa) (section 10.
- Development of the Rotterdam-Duisburg/Dortmund service exploiting the Betuwe-Lijn by KV. A description of this demonstration activity is included in the DA 5.1 report.

2.2 Expected results

A major milestone of this workpackage is to define an optimized maintenance concept for the Betuweroute. Furthermore, seamless operation of ERTMS equipment (both trainborne and trackmounted) from different suppliers is to be achieved.

3. The Betuweroute and the CREAM-corridor

3.1 Introduction

One of the CREAM corridor sections is the Betuweroute.

In 1990, a first plan for the Betuweroute was developed. Costs of this initial plan were estimated as € 1.13 billion. The aim was to increase the capacity of an existing old and outdated regional railway line, called the Betuwelijn. This idea was abandoned because it did not fulfill the requirements. The finally realised infrastructure is much different from this initial plan. A new trajectory was chosen (change of location). Next, the project was both slimmed down (no north-east and south branches) and extended during the construction period (change of scope). The project was extended to include major parts of the railway network and terminals in Rotterdam Port (‘Havenspoorlijn’), marshalling yard Kijfhoek, and four new tunnels. The final decision to start the project was taken in 1996 and construction works started in 1997. Network manager ProRail was given the task to construct the Betuweroute for a budget of € 3,744 billion (± 20 percent) [2].

Table 1. Development of building costs of the Betuweroute

Description	**Budgetted (31-12-2006)**
First plan for the Betuweroute in 1990	€ 1.13 billion
Budget for Trajectory Decision in 1996	€ 3.744 billion
Price increase in the period 1996 tot 2007	€ +797 (1)
Scope changes and technical risks	€ +127 (2)
Projected total costs (including risks)	€ 4.668

Notes:
(1) Price inflation. For large projects with long construction periods, the impact can be serious.
(2) Scope changes include increased safety requirements, additional noise shielding, and the connection with the existing rail network (all political choices). Technical risks are e.g. risks related with a new tube drilling technology.
Source: www.betuweroute.nl.

The main features of the Betuweroute are presented in table 2.

[2] TCI (2004) is an extensive assessment of the decision-making process regarding this railway line.

Table 2. Features of the Betuweroute

Characteristic	Value
Length	160 kms
Parallel to motorway A15	95 kms
Length of noise barriers	160 kms
Number of fauna ducts	190
Number of tunnels	5
Length of tunnels	18 kms
Number of bridges and viaducts	130
Length of bridges and viaducts	12 kms
Number of overhead powerline portals	5.600
Number of sleepers	600.000
Number of switches	155
Length of lowered track	7,5 kms
Sand required	16 million m^3
Number of buildings removed	400
Man-years of work	20.000
Power supply system	25 kV
Safety and security system	ERTMS
Allowed maximum speed	120 km/h
Allowed maximum axle load	25 tons
Allowed maximum capacity	10 trains/h (both to and from Germany)
Officially opened	16 June 2007
Costs	€ 4,668 billion
EU contribution	€ 170 million

Source: De Volkskrant, June 16, 2007.

The Betuweroute crosses 28 municipalities and 2 provinces. Between Rotterdam Maasvlakte and Barendrecht the ‘Havenspoorlijn’ has been upgraded, the next 120 km is a new line. Environmental and liveability concerns led to a route parallel to the A15 motorway as far as possible.

Safety has been a crucial issue while planning and building the Betuweroute. Because of this, there are no level crossings. Systems have been implemented along the line to control the maximum speed of the train, while ‘hotboxes’ detect brake and wheel defects. The line has 5 tunnels with two separate tunnel tubes per tunnel. In the tunnels, automatic sprinkler installations have been installed. In case of fire, special equipment is used to switch off the high voltage supply. The tunnels are equipped with dedicated technical hard- and software referred to as TTI (Tunnel Technical Installations). These precautionary measures make the Betuweroute the safest railway of the Netherlands and one of the safest in Europe.

3.2 Main purpose of the Betuweroute

The main purpose of the Betuweroute is to enable freight trains to evade congested parts of the Dutch main railway network, especially the existing Brabantroute. It offers a fast and reliable rail connection between Rotterdam and its European hinterland. The line is not only connected with Rotterdam port, but also (in future) with Amsterdam port. In the past a north-eastern branch (‘NOV’ towards Zwolle) and a southern branch (towards Venlo) were planned, these were skipped because of several reasons. One was the new policy of ‘use more, then build if necessary’, another reason was that the main project had a cost overrun. According to Keyrail there is a discussion with the minister of Transport and Public Works to include these branches in the infrastructure planning again. With these branches, the ‘attractivity’ of the Betuweroute would increase substantially. However, this would also start a new discussion about environmental and liveability concerns in the built-up areas crossed by these branches.

The Betuweroute itself offers a major saving in transit time. Instead of 2.5 hours it now only takes 1.5 hours to go from Rotterdam to the German border. Due to scheduling constraints actual time savings may be smaller in practice.

3.3 Major innovations of the Betuweroute

The Betuweroute is an innovative project because of the following:

- it is a long distance railway line purposely built for freight trains;
- capacity is managed/sold on a commercial basis and the customer buys guaranteed train paths;
- the aim is to introduce dynamic train scheduling based on an integrated information system covering all major infrastructure objects (terminals, yards, shippers);
- normal maintenance is managed by a 3 year continuity contract instead of the conventional maintenance practice;
- ERTMS and 25 kV power supply systems are new to the Netherlands.

3.4 Keyrail

3.4.1 Roles of Keyrail

In 2006, the Dutch parliament agreed to give a five-year concession to Keyrail. It is a company (with shareholders ProRail (50%), Port Authority of Amsterdam (15%) and Port Authority of Rotterdam (35%)) dedicated to the exploitation of the Betuweroute. Keyrail is responsible for (Keyrail, 2007a, p. 6):

- “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 yards at IJsselmonde and Feyenoord;

- development and management of an incident management organization for the Betuweroute;
- to management capacity distribution and traffic management of the Zevenaar-Zevenaar Border trajectory.”

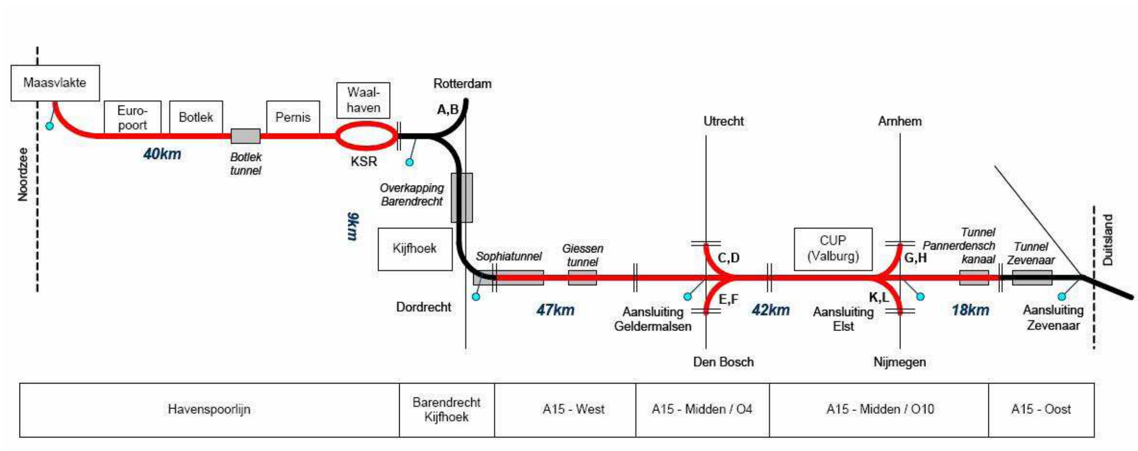


Figure 3. Area managed by Keyrail (‘Beheersgebied’)

Source: Keyrail, 2007a.
Legend: KSR = bypass route in Waalhaven for through trains, Midden = middle section, Oost = eastern section, CUP is (the skipped) container terminal at Elst (now a marshalling yard), aansluiting = connection, overkapping = noise roof, Geldermalsen = Utrecht/Amsterdam connection, Noordzee = North Sea, Duitsland = Germany.

The Betuweroute can be divided into three main sections: Port line (‘Havenspoorlijn’: Maasvlakte-Kijfhoek), A-15-trajectory and Zevenaar-Oost – Zevenaar Border.

3.4.2 Aims of Keyrail

Keyrail developed itself separately from ProRail. Keyrail has a five year concession from the Dutch State to develop the Betuweroute into a commercial success, after which it hopes to extend its contract. It has a number of targets (Keyrail, 2007k):

- cost-covering exploitation for a longer period;
- be so attractive for commercial partners that they are willing to invest in Keyrail;
- a good quality primary product and improved image of rail freight transport (reliable supply, availability etc.) and improved competitive edge of railways vis-à-vis other modalities;
- manage infrastructure in a safe way with minimal hindrance and at the lowest possible costs.

Keyrail supervises track maintenance, while ProRail is responsible for track renewal (for maintenance, read Chapter 5). Keyrail has developed its own access procedure for RUs.

3.5 Exploitation strategy: volume growth and quality

Due to technical and economic reasons, the capacity of the line could not be used to the fullest extent after the railway line was opened. This is why Keyrail adopted a development model (‘ingroeiregeling’: Keyrail 2007a), which foresees a gradual increase in traffic volumes, while maintaining a good quality of service. This is called the ‘volume strategy’ and is the key element of the exploitation strategy. Among the technical problems was the unfinished ERTMS implementation. Due to this and other reasons, like criminal activity (stolen cables of signalling and power supply system), remaining technical installation works and legal obstructions, services started with a very limited number of trains (1 train per 2 hours). With ERTMS not functioning as planned and conventional train signalling and detection being absent, communication between train driver and traffic managers was constrained. This is why the whole A15-trajectory was technically treated as one signalling ‘block’, allowing only one train in the same corridor. Locomotives needed a special permit to get access to the line. With the arrival of locomotives equipped with a compatible version of ERTMS and a technical allowance to use the Betuweroute, the capacity of the line could be increased. Since June 2008 four trains per hour per direction are allowed on the A15-trajectory. The maximum capacity is reached with twenty trains/hour (2x10).

During the start-up phase a special regime was used. Locomotives with ERTMS on board units (OBUs) and track allowance (like the BR189 electric locomotive) fulfil VGB3 requirements (VBG3 = Declaration of Acceptance 3 or ‘Verklaring geen Bezwaar 3’ or ‘VGB in exploitatie’). They could be freely used during weekdays. Locomotives with VGB2 (‘VGB commercieel proefbedrijf’ or test phase) fulfilled the requirements of the ‘restricted access regulation’ or ‘Gebruiksregeling’. They were allowed on Sundays between 16.00 and 23.59 hours (Keyrail, 2008a). Railion ordered a large series of ERTMS-equiped locomotives, but its competitors were hesitant, which, together with its 80% market share, explains why Railion was the main user of the Betuweroute during weekdays, while its competitors mainly used it on Sundays. The inflow of ERTMS-equiped locomotives enabled termination of this special regime in June 2008.

With the arrival of enough locomotives equipped with ERTMS Level 2, the government and Keyrail have finished the development model (‘ingroeiregeling’) in September 2008. This marked the start of the five year exploitation period (Ministerie van Verkeer en Waterstaat, 2008). The second phase of the exploitation strategy foresees a growth in market share of rail freight transport, due to customized services and products.

3.6 Summary

The Betuweroute is a railway line purposely built for freight trains. It connects the Rotterdam harbour area with Germany (and beyond). It was built because the existing mixed railway lines to and from Germany have limited capacity, while crossing urban areas of high density.
The Betuweroute consists of two major parts: the Port Line and the A15 trajectory. The Port Line consists of all rail tracks and facilities (like yards and RSCs) in the Rotterdam harbour area (exclusively) open to freight trains. The A15 trajectory is the section of the Betuweroute outside the Rotterdam harbour. Other parts of the Netherlands, including the Amsterdam harbour, are connected with the A15 trajectory.
The Betuweroute contains various innovations. First is the commercial capacity management of the railway line. Second is the innovative maintenance contract. Third are a functioning 25 kV power supply system and an ERTMS/ECTS signalling system (Levels 1SH and 2).
Keyrail manages capacity on the Betuweroute for an initial 5-year period, while Strukton is the main contractor and coordinator of all regular maintenance activities.
Due to various factors capacity could not be used fully from the start. Once the quality of the infrastructure is of the required standard, more trains can use the Betuwroute per hour. This leads to a exploitation strategy called “volume strategy”.

4. Technical-economical analysis

4.1 Introduction

This section is dedicated to the first task of RA 5.1:

“Describe and analyse the technical and economic prerequisites for an efficient integration of the Betuweroute in the European rail network.”

In this section we will elaborate the following issues:

- interoperability (section 4.2)
- advanced train management and scheduling (section 4.3)

4.2 Interoperability in railways

Interoperability 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)

The concept of interoperability and the reasons why it is so vital for the future of European railways have been described very well by the following (CZ, 2008, slightly adapted):

“The competitiveness of the railway system is dependent, at the moment, on the differences between the Member States in terms of materials, technology, signals, safety regulations, braking systems, traction current and speed limits.

The international trains which cross many States are forced, by this situation of system segmentation, to stop at the "border".

The technical differences between the European states, over the years, have been due to the need to protect their particular interests or those of the respective rail industries, but at the same time, it led to a reduction in the traffic quotas. Road transport, on the other hand, strengthened its market position by taking advantage of the absence of technical and logistic barriers.

European railways cannot guarantee transit times in international transport (50% of rail freight traffic crosses at least one border). The lack of harmonised networks reduces quality of service and, therefore, competitiveness.

Moreover, the technical and regulatory barriers have direct consequences for the transport market: They favour the existing firms and slow down the entrance of new operators and the development towards a more competitive market.

An open market, without technical barriers, is the best guarantee for an increase in the quality of the services offered (the firms are forced to compete with one another) and for an expansion of the demand. At the same time, it is the opportunity to make new investments.

The interoperability represents one of the absolutely essential factors for the revival of rail transport and the consequent rebalancing of the general transport market. Thanks to the interoperability and the construction of a railway sector which is legally and technically integrated and commercially competitive, even the aim of reducing traffic congestion on the EU roads becomes possible, with the reduction of pollution and clear advantages for the environment."

The role of the EU

In the nineteen nineties, the EU realized the importance of interoperability and issued its Directives on the interoperability of the high-speed (96/48/EC) and conventional (2001/16/EC) trans-European railway systems, urging RU's and national governments to take the necessary measures to reduce the differences with neighbouring railway networks, in order to improve the circulation of the international trains when they cross the frontiers, searching for common standards for

- signalling and commands
- telematics applications for freight transport
- operation and management of the rolling stock to be used for international transport
- qualifications of personnel
- etc.

With interoperable networks, the railway customers benefit from a safer, faster and technologically advanced transport system

The technical counterpart of these legal EU declarations are TSIs (Technical Specification Standards), especially those for Control Command and Signalling and Rolling Stock and Operations (RINA et al., 2007).

These Directives and TSIs define the roles for the Member States. It is however the responsibility of th Member States to put a new line into service or upgrade an existing line. A very important implication of this is that in specific cases national solutions have to be found, which may reduce interoperability (RINA et al., 2007). We will come back to this vital point in section 9.4

4.2.1 Interoperability on the Betuweroute

The Betuweroute is different from other railway lines in the Netherlands, because it employs at least two different technologies, which could be used to reduce barriers for interoperability. First, the line is equipped with a 25 kV AC power system instead of 1500 V DC as found on the rest of the Dutch railway network. 25 kV AC is to become the European standard for railways. 25 kV enables locomotives to pull longer and heavier trains. A standard voltage everywhere in Europe removes voltage changeovers, hence the need for either changes of locomotives at system borders (lower operational costs) or the use of more expensive multi-system locomotives, like the Siemens Dispolok (Series 189). 25 kV AC is not compatible with the Germany 15 kV 16.7 Hz AC power system, hence the use of multisystem locomotives for Dutch-German freight trains.

Second, the line is equipped with ERTMS (European Rail Traffic Management System) instead of ATB-EG (or ATB first generation) as found on (most of)the Dutch railway network. An additional signalling system introduces an additional system changeover to rail freight in this part of Europe, at least in the short term.

4.3 Advanced train management and scheduling

4.3.1 Introduction

In (international) rail freight transport, there is a major difference between what train scheduling and how trains actually run. Many trains are not on time (most of them delayed, some arriving too early). In international rail freight transport 80% of the causes are statistically categorized in a rather broad category – so-called transfer of trains, which reflects the complex logistic structure of railways. This makes it difficult to track down the party ultimately responsible for an off-schedule train. Long distance trains are particularly vulnerable, because they are usually discriminated compared to (inland) passenger trains. Crossing a border introduces additional vulnerabilities into the system, like customs supervision, technical checks and change of locomotives and drivers.

These exchange procedures increase operating and asset costs (Wendel, 2007a). This is why there have been varies attempts to remove or relieve such barriers. In the ideal situation, a managed transport corridor would replace the existing fragmented network organization, with trains running (more) on time, with up-to-date information about train position, the possibility to reroute or modify schedules etc. Such organization and information are regarded as critical in road transport and if rail transport wants to become more attractive, it should be able to provide its customers with the same (customized) logistic product, because off-schedule trains directly influence the business of the customer. In such

an international corridor, one organization would ultimately be responsible for train management. The EU has decided to upgrade six international rail freight corridors. The one relevant for this report is the Rotterdam-Genoa corridor.
In this section, we will describe how the Betuweroute, which not only belongs to the CREAM-corridor, but also to the Rotterdam-Genoa corridor.

4.3.2 The Betuweroute and corridor management

Keyrail uses the following tools to manage trains on the corridor Rotterdam-Zevenaar (Keyrail, 2007b):

- access permit and use of infrastructure by RU (4.3.2.1)
- allowed locomotives and rolling stock by RU (4.3.2.2)
- allowed operations and staff of RU (4.3.2.3)
- delivery of information by RU (4.3.2.4)
- distribution of capacity to RUs (4.3.2.5)
- Keyrail services to be contracted (4.3.2.6)
- quality of services and assumed behaviour (4.3.2.7)
- user charges (see section 8)

The Dutch documentation provided by Keyrail is translated and summarized in this document. This report is not intended as a detailed guideline to learn about specific procedures, only as an introduction into such procedures. The reader is referred to the references and Keyrail for further (bureaucratic/legal/technnical) details.

4.3.2.1 Access permit and use of infrastructure

The Betuweroute is a separate part of the Dutch railway infrastructure. It consists of mainline railways, secondary (branch) lines and other infrastructure, including terminals and marshalling yards. At specific points it is connected to the railway network managed by ProRail. Such connections have a technically and operationally different regime. In this case, there exists a different power and signalling system and traffic regime. On ProRail infrastructure and in neighbouring countries, like Germany, mixed traffic is allowed, which means that locomotives must have multiple on board power-, signalling- and communication systems. Freight trains do not have a guaranteed path like they have on Keyrail infrastructure.

Access to the infrastructure is allowed to companies, who signed the so-called Net Declaration (‘Netverklaring’) of Keyrail. Keyrail is member of RailNetEurope (RNE), an initiative of 30 thirty European rail infrastructure managers to develop and sell rail infrastructure (slots) in Europe. To that aim they harmonise the access conditions, procedures and processen in their rail networks. To reduce administrative procedures, each member of RNE has organised a single sales office called One Stop Shop (OSS), which has the following tasks:

- delivery of information to RUs and other relevant parties about access to its infrastructure;
- request for capacity for each international train path within RNE (Pathfinder communication system);
- request for capacity for domestic traffic;
- to warrant that requests for the next scheduling period are properly included in the scheduling plan for the next period;

In principle two kinds of requests for capacity can be granted:

- to RUs, which they can use to run their own trains. This is the full access permit ('Toegangsovereenkomst' ; Keyrail, 2007a);
- to intermediaries, which they can use to reserve, but not use capacity on behalf of RUs. The latter is called the restricted permit ('Capaciteitsovereenkomst').

In order to use the Betuweroute, a RU should

- own a valid operational permit ('Bedrijfsvergunning') or a similar document;
- own a safety certificate ('Veiligheidsattest') or temporary certificate ('Proefattest');
- be insured for at least the legally required amounts per accident;
- have signed an access agreement with Keyrail ('Toegangsovereenkomst').

Keyrail has a five year (renewable) mandate to provide commercial services based on so-called Permit Regulations ('Bevoegdheidsregelingen: BR), General Operational Rulings ('Generieke Operationele Regelingen': GOR) and General Conditions of service ('Algemene Voorwaarden': AV). In a BR, Keyrail describes how it will fulfil its mandate. Keyrail accepts BR change requests by RUs. GORs describe operational details. They have a contractual status and are made by Keyrail after discussion with the RUs. In a Toegangsovereenkomst, Keyrail describes which BRs will be applicable. Keyrail and the RUs make an agreement on the applicable GORs.

Special rulings are applied to non-standard locomotives, wagons and load. Keyrail may temporarily exclude a RU from the standard requirements or the Basic Access Package

('Basistoegangspakket') via a Ruling for Exceptional Transport ('Regeling voor Buitengewoon vervoer').

For dangerous goods, the standard Dutch safety and environmental laws and regulations apply, while for special infrastructure like tunnels special installations (TTI) and additional requirements related with safety are in place, which may limit the number of trains in such tunnels per unit of time [3], hence reduce capacity. There is also regulation preventing that trains with non-allowable goods use (specific parts of) the Betuweroute.

In case of cross-border transport, exemptions are only valid after agreement with the German DB Netz or the Belgian Infrabel network managers.

4.3.2.2 Allowed locomotives and rolling stock by RU

Any rail vehicle should, before it is allowed to use mainline infrastructure, have a Permit for Use ('Inzetcertificaat'). This permit is an extension of the Technical Acceptance Certrificate ('Goedkeuringscerticificaat') or the EU Technical Acceptance. Coaches and wagons are excempted from this requirement if they fulfil the latest version of the RIC or RIV conditions and their wagon numbers are mentioned in the national vehicle register. Rail vehicles employed on mainlines should be regularly maintained in order to keep their permits.

The Toegangsovereenkomst also governs secundary lines managed by Keyrail. Coaches and wagons are allowed access to these lines if an Notified Body has given them a permit. RIC and RIV conditions have to be met as well.

Other rail vehicles are permitted after an allowance research dealing with technical compliance and prevention of damage to the infrastructure is positive.

Railway vehicles should fulfil noise emission requirements. A certicifate should warrant this, in compliance with the GOR Acoustical Data Rolling Stock ('GOR Akoestieke gegevens spoorwegmaterieel').

In order to limit wear and tear to the rails and warrant railway safety, Keyrail has a particular interest in the prevention of wheelband irregularities. To ensure this, Keyrail will perform measurements of dynamic stress of rails. Switches and curves are particularly vulnerable to mechanical stress. Keyrail is allowed to instruct locomotive drivers in specific circumstances how to prevent such unwanted situations.

[3] For instance, in the 8 kilometers long Sophiatunnel between Kijfhoek and Papendrecht, south of Rotterdam, currently only 1 freight train per direction is allowed by safety regulator IVW. This makes this tunnel a real bottleneck, limiting the capacity to 1 train per 15 minutes.

Next to these conventional (technical) requirements, additional technical requirements arise from the use of ERTMS. They will be discussed in section 9.

4.3.2.3 Allowed operations and staff of RU

The key principle here is that any staff directly or indirectly employed on the Betuweroute should fulfil the requirements of the Railway Law ('Spoorwegwet'). From this it follows that staff is properly trained in the safety aspects of railways and behaves in a competent manner when carrying out processes related with running trains.

In case of normal operations, staff should promptly and swiftly communicate train parameters like train numbers, composition and loading of trains.

Staff should be trained in dealing with incidents, accidents and 'alerting situations' (defective infrastructure, environment threats, terrorism). It should communicate any observations in these areas promptly and swiftly with Keyrail.

Keyrail is allowed to contact RUs in case of non-compliant operations if such operations reduce efficient use of infrastructure, or cause damage and hindrance for Keyrail, other traffic and/or the environment. One of the requirements in this area is that a specific train should be able to maintain the planned speed for the respective train path.

4.3.2.4 Delivery of information by RU

Operations of RUs should be properly documented. On request an RU should provide Keyrail information supporting capacity requests, just before and after actual use of the infrastructure. Next to that, the RU should provide statistical information for specific time periods.

4.3.2.5 Distribution of capacity to RUs

Two issues will be elaborated in this section. The first one is the procedure by which Keyrail distributes the available rail capacity (train paths) over the (requests from) RUs and intermediaries. Second is a description of a tool developed by Keyrail and its customers to better manage available capacity. It is called Pilot Chain Management ('Pilot Ketenregie'). Third is a description of the capacity change management ('bijsturing' in Dutch) by VL.

Available capacity is determined as follows. Proper maintenance is the key to successful use of infrastructure. This explains why Keyrail first reserves capacity for maintenance. The residual capacity is then open for distribution via the procedure for capacity requests to RUs and intermediaries.

Capacity distribution

The Dutch Railway Law contains a procedural elaboration of EU Directive 2001/14/EG concerning a honest, acceptable and non-discriminating way of capacity distribution. In global terms, capacity related to the Basis Package (see later) is divided as follows:

- Keyrail and a RU agree on capacity distribution (matching demand and supply);
- For each segment of the transport market minimum capacity levels are determined covering the whole Dutch railway network, including the Betuweroute;
- Sections of the infrastructure marked as ‘excessively used’ (‘Overbelast verklaard’) will be used according to legally binding priority rules;
- There are procedures to distribute capacity to maintenance activities;
- The Dutch Antimonopoly Agency (NMa) will govern the proper execution of legal requirements concerning capacity distribution and deal with complaints by RUs concerning the process and content of this distribution.

Train scheduling consists of two main processes:

(1) Processes to prepare the capacity distribution;

(2) Processes to distribute capacity.

Ad 1) Preparation

Keyrail distinguishes three types of train paths:

- standard train paths: applicable on the whole Betuweroute and on the A15-trajectory also for single locomotives
- single locomotive paths and local traffic paths: only on the Port line.

Keyrail, after consultation with RUs, develops so-called Standard Patterns (‘Standaard Patroonpaden’) for the whole Betuweroute.

This pattern is not a formal distribution, but a tool to be used by stake holders to match capacity requests on an hourly, daily or weekly repeting basis. When making the schedule with train paths, Keyrail will take into consideration available capacity at yards.

At the moment of writing this document, the following train paths (trains per hour, per direction) was offered by Keyrail:

- Kijfhoek-Meteren: 4 (restricted because of the current safety regime of the Sophia tunnel at Barendrecht)
- Meteren-Zevenaar: 8
- Zevenaar-Zevenaar Border: varies, depending on the distribution between passenger (ICE) and freight trains

- Kijfhoek-Pernis: 10 (plus paths for single locomotives and local traffic)
- Pernis-Maasvlakte: 7 (plus paths for single locomotives and local traffic)

Single locomotives are allowed on the A-15 trajectory if they can use non-used train paths. At the Port line at least 2 additional paths are available for single locomotives plus more if train paths are not used, while single locomotives may also use paths along the bridge between Maasvlakte and Pernis.

About 140 trains per week use the Betuweroute, this should increase towards 140 trains per day.

Keyrail will see to it that the set of train paths is available at such a moment in time, that the best match is made with the standard pattern of train paths called Basic Hourly Patterns ('Basis Uur Patroon': BUP) of ProRail. This is necessary because the Betuweroute crosses ProRail tracks at Elst, Meteren/Geldermalsen (direction Utrecht/Amsterdam port), Kijfhoek, IJsselmonde, Zevenaar. Keyrail also has to assure proper matching with the Hourly Patterns ('Stundentakt') of DB Netz.

The maximum speed used in the schedules at the Port line is 60 km/hour per path and on the A15-trajectory this is 80 km/hour.

The train paths as discussed here are meant for complete trains. Requests for paths for single locomotives are dealt with by the traffic management (or VL).

Ad 2) Distribution process

Keyrail divies planning into four layers (see Table 3). Each has its own time window.

Table 3. Four layer planning model

Phase	Request moment	Standaard pattern of paths	Single loc paths	Local traffic path
1. Year Plan	2nd Monday in April	Structural requests	NA	NA
2. Change Sheets	Approx. 5 per year	Structural requests	NA	NA
3. Day Plan	2 month -> VL	Non-structural requests	NA	NA
4. VL (Traffic management)	Day Plan -> 4 hour`s before ETD	Non-structural requests	NA	NA
	4 -> 1,5 hours before ETD or border crossing	Non-structural requests, only from ProRail/DB	Non-structural requests	Non-structural requests
	1,5 -> 0,5 hour before ETD	NA	Non-structural requests	Non-structural requests

Keyrail wants a train path planning that is robust and predictable, by limiting the number of changes and cancellations. The bonus-malus ruling and the cancellation ruling are meant to stimulate RUs to reduce the number of changes of already distributed train paths or at least stimulate RUs to communicate such changes as early as possible.

Keyrail is also entitled to take back unused train paths. If a RU does not use capacity for less than 50% in a period of 8 weeks, Keyrail will contact this RU, eventually proposing a redistribution of train paths to other RUs. For the VL-phase a more direct ruling is employed: if process steps are not followed, the path is cancelled.

These rulings are only enforced if the RU is to blame.

The Year Plan

The Year Plan contains train paths with at a minimum a weekly recurring pattern for a period of one or more published Change sheets (‘wijzingsbladperiodes’). This is called a pattern of train paths.

Keyrail develops and employs the Year Plan in a much different way than comparable infrastructure managers like ProRail. To be mentioned are the long (pre-)planning period, the reliability of the sold train paths (guaranteed and agreed with ProRail), the reservation for maintenance (so-called OHR or ‘OnderHoudsRooster’), the interaction with users and the flexibility of long-term (Change Sheets) and short term planning.

The planning process starts (see Figure 4) with the development of a Pattern Plan phase (PP) between September 1 and December 1 of the year before the PP is to be used. The PP is ready in concept on December 1. The PP includes a scheduled reservation for maintenance [4]. This planned reservation of maintenance is an innovative feature, not found elsewhere.

To allow flexibility, maximum traffic intensity is defined as 80% of the maximum capacity (unlike Germany where it is 100%). A path has a 90-120 minutes buffer (‘overstand’) to allow a flexible move from the A15-trajectory to the Port line.

Six weeks later the PP is published as a catalogue (on January, 14). This provides every customer with a real and transparent picture of available capacity.

Then the Year Plan phase starts with the stage of capacity requests [5] according to the internationally agreed (RNE) guidelines. Between January 14 and April 14 users can send in requests for train paths. The standard train paths are offered as secure paths, agreed with ProRail (fitting in the so-called Basic Hourly Patterns or ‘BUP’). A train path is made as a

[4] Large-scale renovations of the infrastructure (extensions, bypasses etc.) and maintenance on behalf of third parties (e.g. for road tunnels) are a separate process.

[5] All requests except those related with the Year Plan are treated according to the ‘first come, first serve’ principle. Note that all dates mentioned were applicable in 2008.

‘fluent path’, which means that there is a 90-120 minutes buffer at Kijfhoek marshalling yard to connect the A15 trajectory with the Port line.

On April 22, division of capacity (so-called ‘programmatie’) starts. Then Keyrail analyses the capacity requests for potential conflicts (in case more than one potential user requests the same path) and connectivity with the Dutch (ProRail) and German (DB Netz) train path scheduling. A technical meeting in which border areas are discussed is scheduled in the period June 23-26 (in Freibourg). The results of this meeting are dealt with by Keyrail in the week after.

Potential conflicts are managed in a way different from the ProRail practice. ProRail asks its customers to solve conflicts in discussion sessions with all potential users (‘tafel van verdeling’), while Keyrail has a 1:1 discussion with each customer. In this discussion, Keyrail asks the customer what options it sees to solve the conflict.

On July 7 the results of the analysis are available and included in a concept train schedule also known as ‘path offer’(RNE, 2006). This contains ‘conflict-free’ trains. It is either based on concensus or decided by Keyrail (in a so-called ‘programmatievoorstel’).

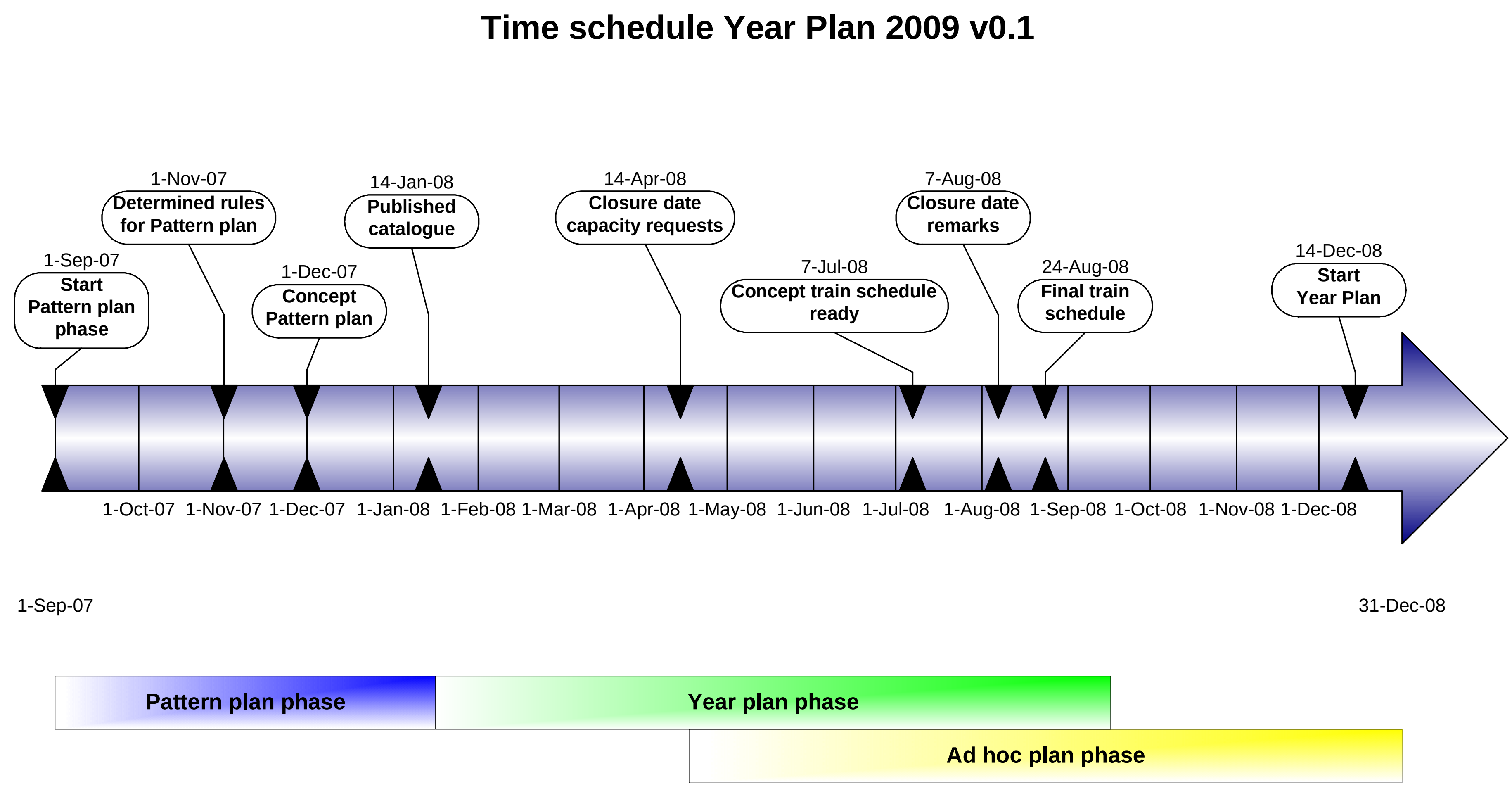


Figure 4. Keyrail Planning schedule for Year Plan 2009

Next, the consultation phase of one month starts in which customers can sent in their comments and remarks. Between August 7 and August 22 Keyrail makes final decisions and publishes the Year Plan for the coming year. Until August 14 'late path requests' are accepted. In the consultation phase the applicant either accepts the path offer or starts a legal procedure. The period between April 22 and September 2 is called the settlement period ('beslechtingsperiode'). In this period also legal procedures (via the Dutch anti-monopoly agency NMA) can be carried out.

A final decision is made by the network manager Keyrail. The new Year Plan starts about 3,5 months later (on December 14).

In April the so-called ad hoc plan phase starts, allowing for dedicated changes (e.g., to adapt to changes in terminal opening hours or new business opportunities) throughout the remainder of the year. Requests have a lead time of 6 weeks, otherwise they will be handled as 'daily requests'.

In the present situation, Keyrail and ProRail have independent discussions with users. This is inefficient as it may lead to conflicts. To prevent them, the possibilities for common 'conflict-free' agreements are being investigated between Keyrail and ProRail. Here, capacity requests which do not lead to conflicts are immediately accepted.

Dayly/Ad hoc Traffic Plan

Operators can request train path at the One Stop Shop (OSS) of Keyrail. Requests have to fulfill a specific format. OSS makes a first administrative check to see whether the request fulfills the requirements (is it complete?). Then the request is sent to the planning department of Keyrail for order processing. All requests are collected, jointly considered and transferred into a concept train path schedule.

Then this schedule is sent to the RUs for approval. If they agree, train paths are divided over the RUs. If the RUs do not agree, then a most suitable solution has to be found by the co-ordinator (Keyrail). This solution is then included into the new train path schedule.

The train path schedule is used to adapt the catalogue of train paths, which is published later.

The planning process is not optimal at the moment. Things to improve are the following:

- to develop connecting train paths
- performance measurement (KPI check internal)
- incentive contracts for Keyrail and the RUs

Delayed trains

Keyrail is monitoring trains which are too late by at least 3 minutes. Data about such trains is recorded together with the causes of the delays. Keyrail is using an existing ProRail system, which is extended in order to fulfill the monitoring function.

Future situation

In 2009, 8 paths per hour will be available instead of the current 4.

There is a discussion about north- (towards Deventer) and southbound (towards Venlo) connections. This would enable a better division of traffic and enable a much more flexible use of the Betuweroute. The connection with Utrecht/Amsterdam Port will also be improved. At Elst the curved track connecting the Betuweroute with the conventional network is too short for trains of normal length, so there is need to reconstruct this curve. According to Keyrail the third track towards Emmerich (discussed in section 9.3.3.3) is not enough to accommodate the growing traffic in the very long term. With the Betuweroute the Netherlands are at the forefront, necessitating Germany to invest millions of Euros in the rail infrastructure.

Another change in 2009 will be that operators will receive a complete train schedule listing all train numbers and stopping times. This is comparable to the situation that already exists in Switzerland.

The idea is also to have regular discussions with operators in which small problems can be solved (so-called ‘afstemmingsmomenten’).

ProRail has learned from Keyrail’s experience and has decided to start using a catalogue of train paths as well. The idea is to contact all operators in September in order to collect their prognoses about future path requests. In October Keyrail and ProRail come together to discuss the requests.

It has become clear that the existing traffic management software VPT-14 has to be replaced, because it is not is not future-ready, not user-oriented and not neutral towards RUs. Future-readiness refers to the demand for transport and node management. Lack of rser-orientation refers to the fact that very early in the planning process many things should be already known and the time-consuming process of data entry updates, due to the many modules and re-iterations. VPT was developed for a situation in which only one infrastructure manager was managing traffic and only one rail operator, NS, was running trains on the Dutch rail network. Later, NS was split into separate passenger and freight departments. NS Freight was then sold to DB (now known as Railion NL), but the old ICT-infrastructure was inherited and NS ICT remained responsible for capacity distribution. This leads to conflicts of interests in a situation with many RUs.

The idea is that in 2010, the situation will be much different. A new integrated computersystem will replace VPT. ProRail started the development of what was first called redesign planning process or HoPp (‘Herontwerp Plan Proces’) to replace VPT. A train observation and tracking system (so-called TROTS) will be introduced together with new Linux-based planning software PTI (‘Planning Toedeling Infragebruik’). In 2006 HoPp was renamed into DONNA. DONNA should give immediate information about free train paths. It is web-based, has access right control and other modern soft- and hardware characteristics, unlike VPT, which is from the DEC VAX-VMS age. History shows however, that changes in ICT architecture in railways can take more time than expected. Decision-making is slow and very complex due to the many parties involved and the complex demands of railways (Computable, 2007; Railpedia, 2008).

Incomplete documentation

An important issue to solve is how to convince RUs that they have to provide sufficient information to Keyrail about their trains. In practice, 30% of the wagon documents is not available. This includes wagons loaded with chemicals. Keyrail can't stop these trains, however there is a legal obligation to accompany trains with adequate documents. Without such listings, handling these trains takes more time.

Keyrail has to find a way to discipline the RUs. It tries to achieve this by checking the trains.

Growing traffic; (potential) conflicts

A typical conflict arises when VL (Traffic Management) decides to accept a(n international) train, while there is no space to park this train. This contributes to congestion and may eventually generate so-called 'excessively used tracks' (special regime called 'overbelastverklaring'). What to do? Both the RU and Keyrail have a commercial interest to accommodate trains. To solve this and other issues, the project Ketenregie (see below) was initiated.

(B) Pilot Ketenregie

Many freight trains arrive either too late or too early. Keyrail has analyzed this issue and the consequences of this problem (Keyrail 2007c-f). Two main causes of irregularities are:

- reporting of changes in ETA "not overwhelming"
- "loc/driver on time is exception rather than rule".

This means that RUs are (were) not able to organise their business in a way that is beneficial to the network. Inefficient use of the Betuweroute is not in the interest of the RUs as it increases transit times and reduces reliability of transport. In fact, Keyrail, instead of being customer-oriented, it was giving-in all the time, solving their problems.

All relevant stake holders agree that the improvement of the transport chain should be a common objective, yet competition stands in the way of co-operation.

This is why the Pilot Chain Management ('Ketenregie') was started. Its aim is to increase punctuality with 20% on the Port line in the short term, to improve the overall quality of rail transport, to reduce costs and increase efficiency of the Port line (allowing more throughput).

To get the best results, the pilot is limited to a small number of actors – the main terminals (ECT, RSC), RUs (ERS, Railion, Veolia) and operators (ERS, Hupac, Intercontainer). To Keyrail, terminals are of equal importance as neighbouring infrastructure networks (Keyrail, 2008d). Keyrail is project manager and Rotterdam port authorities support the Pilot. Other stakeholders are informed via documents and meetings. The idea is that all RUs fulfill the requirements as of August 11, 2008.

According to expectations, traffic can grow with 100% given this new regime, provided the new way of working is accepted by all RUs. For the A15 trajectory agreement with DB Netz is necessary (adjustment of regimes).

The Pilot Ketenregie could have the following quick wins:

- real time reservation of yard tracks at Keyrail
- replanning with central coordination
- operational rules for the whole chain on the Port line
- all parties will be connected to the Traffic Management Information System (ISVL)
- reductions of partial (on/off) shuttles (‘opstapshuttles’)
- joint planning of specific trains.

In order to better use the available tracks a plan was developed and put in practice since December 9, 2007. *The main idea is that only trains with a terminal slot are allowed to pass through the process tracks of the Port line.* If a train does not have a terminal slot, it is not allowed to continue, but it has to wait at Kijfhoek and not block one of the process tracks near the Maasvlakte-, Botlek- or Waalhaventerminals. So, Kijfhoek is used as a buffer.

The plan consists of the following:

1) A new operational model for the Port line developed by KEYRAIL, terminal operators, shippers and operators. It provides a joint and realistic planning of trains at a tactical and a dynamic level. The model should show the planned use of capacity in terminals and (marshalling) yards;
2) Improved organization (train scheduling, 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;
4) Management information generated by the ICT system:
   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. the new ICT system supports the development of the Year Plan (weekly repetitive planning of train paths), the development of the Day Plan end replanning (latest ETA and ETD) at the level of track sections. To enable this, the ICT system should include calculation logic concerning terminals slots (dynamic), process time at yards and driving time. The system should enable analysis of planned and real planned and actually operated times and be able to tell the causes of differences between planned and operated times if such differences are larger than a previously accepted norm;
f. The system should also act as a communication tool between KEYRAIL and the other operators in the transport chain. The system should act as an information base for all actors to get relevant information in and out in order to optimize their operational processes; ETA, train scheduling, if it is possible to attain a train path, staff planning, information concerning loading and unloading, terminal capacity planning, what to do with 'out of time window' containers, 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.

The new way of doing things would enable KEYRAIL to
- communicate changes in the train scheduling to the operators.
- tell what the different players in the chain have to do and when in order to optimize train movements.

The Pilot has achieved a measureable impact. A new integral planning of container trains could be introduced, which made it possible to substantially improve the flow of loading and unloading trains (Keyrail, 2007g).

(C) Capacity change management by VL

Keyrail is entitled by law to change an agreed distribution of train paths in the following situations:
- in case actual running of trains deviates substantially from what was planned and this leads to disturbance of the flow of other trains or railway processes, including an out-of-control situation
- in case of disturbances or unforeseen reductions of available infrastructure
- if state officials demand so
- in case of foreseeable danger
- to prevent a violation of applicable regulations Keyrail has to fulfill

- to finish situations which violate applicable regulations Keyrail has to fulfill
- in case of foreseeable intervention by legal bodies and to prevent its consequences.

Measures in this area aim to maintain security and a return to a situation of intended running of trains in a manageable way. Several situations can be distinguished, from reduced capacity (‘versperring’in Dutch) to delays with normal availability of infrastructure.

According to its concession from the State, Keyrail has to fulfill certain quality criteria. The quality of capacity change management is rergarded as an indicator of the quality of its management of the main rail infrastructure. In international transport, this can be translated into the way connections are guaranteed. Keyrail 2007b (section 4.8) contains more details.

A Neutral Rail Feeder Organization

Each operator runs its trains mainly with his own locomotives and locomotive drivers. This means that there are many locomotives in the Rotterdam Port (including spare locomotives). There are also many changes of locomotives and staff, which have a negative impact on punctuality.

In principe, a shunting arrangement between RUs could secure that RUs shunt each others trains if they block process tracks. In practice this was not very succesful. In other case RRF (Rotterdam Rail Feeder) was used.

A discussion about the installment of a Neutral Rail Feeder Organization (NRFO) started. The hypothesis is that a NRFO will substantially increase efficiency of using available capacity, increase punctuality and reduce costs. It is also needed to accommodate a further growth of rail freight transport.

The following factors are regarded as success factors for an NRFO:

- business plan (with goals and implementation plan)
- consensus among actors that an NRFO has benefits for all actors in the chain
- neutral organization, treating all operators in the same way, operating transparently
- should not reduce competition between shippers and operators

Things to be agreed:

- scope: area (Maasvlakte-Waalhaven) and trains (NRFO is responsible for all trains except ideal shuttles and intermodal trains?)
- assumptions, such as whether operators are free to use certain services or have to use them
- governance: joint venture?
- finance: asset-based?
- organization: how to include existing companies like RRF?

- management: link with KEYRAIL and terminals
- operations: central control; connection with KEYRAIL and the terminals
- pricing: how to allocate the costs over the actors?
- ICT: functional specification, links with individual information systems like Portinfolink.

To increase efficiency of using tracks, Keyrail favours the removal of flexible shuttle trains (‘opstapshuttles’), which enable operators to extend or reduce train length on demand. Instead, it prefers ‘directional traffic’.

How to go towards a NRFO, various options are available:

- operators keep their own locomotives, but they have to follow much stricter guidelines from the infrastructure manager and terminals
- after a tender a license is given to 1 or 2 actors to act as a NRFO for a limited period of time
- to develop an NRFO as a co-operation between existing organizations

Dynamic terminal slots

The way terminals are used in a network has an important influence on the efficiency of this network. On the Port line there is a number of terminals, which are operated by third parties (not Keyrail). The idea is to streamline the services in these terminals by defining optimisation parameters for each of the activities employed in these terminals.

From the perspective of the network, a ‘terminal slot’ is defined as a set of activities to be carried out at a specified place during a certain period of time. A train is treated at the terminal following a specified list of (standard) procedures. In the ideal situation agreed activities should take place within the time interval specified time for each task. Table 4 gives an example.

Table 4 refers to the optimal (theoretic) situation. In practice many things may happen with a train before arrival, in the terminal and when it leaves the terminal. Problems at one terminal may become relayed to other parts, including terminals, of the network (waterfall effect) or cancel out (in case of minor disturbances).

Table 4. Activities related with terminal slots

<table>
<tr><th>Activities</th><th>Where</th><th>Responsible</th><th>Carries out</th><th>When</th><th>RSC</th><th>ECT</th><th>Yard</th></tr>
<tr><td>Entrance</td><td>Terminal</td><td>RU</td><td>RU</td><td>Priority</td><td>10 minutes</td><td>10 minutes</td><td></td></tr>
<tr><td>Fixing pens [1)]</td><td>Terminal</td><td>RU</td><td>Terminal [2)]</td><td>Priority</td><td>10 minutes</td><td>10 minutes</td><td></td></tr>
<tr><td>Loading</td><td>Terminal</td><td>Terminal</td><td>Terminal</td><td>During</td><td>10/hr</td><td>12/hr</td><td></td></tr>
<tr><td>Unloading</td><td>Terminal</td><td>Terminal</td><td>Terminal</td><td>During</td><td>10/hr</td><td>12/hr</td><td></td></tr>
<tr><td>Small brake test</td><td>Terminal</td><td>RU</td><td>RU</td><td>After</td><td rowspan="6" colspan="2">30 minutes</td><td></td></tr>
<tr><td>Container o B</td><td>Terminal</td><td>RU</td><td>RU or terminal</td><td>After</td><td></td></tr>
<tr><td>Wheels on rails</td><td>Terminal</td><td>RU</td><td>RU or terminal</td><td>After</td><td></td></tr>
<tr><td>Techn check LU</td><td>Terminal</td><td>RU</td><td>RU or terminal</td><td>After</td><td></td></tr>
<tr><td>Labeling DG</td><td>Terminal</td><td>RU</td><td>RU or terminal</td><td>After</td><td></td></tr>
<tr><td>Wagon cont check</td><td>Terminal</td><td>RU</td><td>RU or terminal</td><td>After</td><td></td></tr>
<tr><td>Departure [3)]</td><td>Terminal</td><td>RU</td><td>Terminal</td><td>After</td><td>10 minutes</td><td>10 minutes</td><td></td></tr>
<tr><td>Big brake test [4)]</td><td>Yard</td><td>RU</td><td>Terminal</td><td>After</td><td></td><td></td><td>60 minutes</td></tr>
</table>

Notes:
[1)] Not for bulk cargo wagons (like Fccps)
[2)] Present situation
[3)] ETD = start of departure
[4)] Including check of safe running

This is why the idea of dynamic terminal slots was developed.

To introduce dynamic terminal slots, it is, according to Keyrail necessary to make an agreement between stakeholders concerning a list of requirements:

- Operators should commit themselves to provide the number of containers to the terminal:
  - at RSC terminal: at least 2 hours (load and discharge) before arrival
  - at ECT terminal: discharge – at least 4 hours before arrival; load – at least 14 hours before arrival
- Immediately after, but no longer than 4 hours before ETD, the terminal will inform RU about ETD
- Locomotive/driver will be back at the terminal, 30 minutes prior to expected end of Loading/Unloading (L/U), which is 60 minutes prior to ETD
- Transport information will be provided to RU at least 2 hours before end of L/U
- Terminals will include 10% margin in their estimated time for L/U
- In order NOT to change closing times (1 hour before expected end of L/U) and to ensure connection to long haul train scheduling, in principle the end time of the

terminal slot for loading will not be changed ('align right'); start of the terminal slot of other trains in principle will be in line with basic planning ('align left')

- Service Level Agreements (SLA) will be agreed between terminals, RUs, operators and KEYRAIL
- Parties not meeting the above rules will get a penalty
  - Primarily in terms of process steps
    - RSC: removing train + €-penalty
    - ECT: not accepting next train of RU/operator not meeting rules + €-penalty
    - two yellow cards first
  - Penalty will be donated to an 'informal account', clearly indicating 'sponsor'
  - KEYRAIL will not levy additional penalties on RUs.

Use of penalties

- train too early: terminal to yard = no additional parking fees; yard to Kijfhoek = not a changed train and therefore original charges
- train too late: terminal to yard = no financial consequences; yard to Kijfhoek = delayed train and therefore possible financial consequences
- it is clear that penalties have a higher impact on smaller RUs than on bigger RUs.

Table 5. Example of dynamic planning of terminal slot

	Tactical planning	Dynamic planning		
		March 5th	April 6th	
# Containers	30	10	50	50
Report actual #containers	12:40	14:52	10:28	12:40
In	14:40	16:52	12:28	14:40
Start loading	15:00	17:12	12:48	15:00
Closing time	**17:00**	**17:00**	**17:00**	**17:00**
Return loc/driver	17:48	17:48	17:48	20:00
End L/D	18:18	18:18	18:18	20:30
Departure	18:48	18:48	18:48 [1)]	21:00 [2)]

Notes:

[1)] To get long haul slot 'align right'
[2)] If earlier arrival is not possible

According to Keyrail, information about divergencies from ETA and ETD and replanning should be correct and on time available at a central level.

Specific so-called working instructies describe what kind of information should be exchanged between Keyrail and rail operator, and Keyrail and terminal operator, how and when it should be exchanged.

The consequences of non-fulfilment are specified.

At the end of March 2008 an evaluation showed that a significant target was met. Until then stakeholders had a different idea of ‘terminal slots’. As a consequence of this, terminal processes and operator processes were not always synchronised. In the Pilot actors have learned to start the process in the same way and develops his train planning accordingly (Keyrail, 2008b, c). Likewise, terminal operators have started to understand the idea.

Important is the prerequisite that the new definition of a terminal slot will not increase penalties from Keyrail to operators. This also stimulates their cooperation.

Table 6. No additional penalties

	Terminal -> yard	Yard – Kijfhoek
Too early	No additional parking fee	Not treated as changed train and therefore original charges
Too late	No financial consequences	Delayed train and therefore possible financial consequences

Marshalling, what to do with ‘blocking trains’

Capacity is reduced if a train without a locomotive or driver or with technical problems is standing still at a rail section in a yard or terminal not meant for parking. If a terminal or Keyrail monitors this, Keyrail will ask the operator causing the ‘blockade’ to move this train to a different location. The operator has to fulfill this requirement, unless his own ETA or ETD are in danger or legal grounds disallow him to do so. In that case a third party will be asked to shunt the train to a different location. The cost of marshalling is paid by the operator causing the problem. Keyrail determines the alternative parking site. Additional moves after this marshalling are paid by Keyrail.

Terminal closing times

There have been substantial delays at terminals (RSC, Hupac, ECT). Such delays have a major impact on the efficiency of the rail network. Analysis of these delays has lead to the development of a set of rules for terminals. Starting point is a transparent, realistic table with lead times for each terminal with

- T1 - ‘final’ time for containers to arrive at a terminal (< 1,5 hours before ETD)
- T2 - ‘final’ time for containers on wheels (< 2 hours before ETD).

Between T1 and T2 containers can be taken from the stack and loading on to the train (communication between RU and terminal operator).

Containers not available at T1 or T2 will not be accepted and the train will not wait until they arrive.

One of the issues to be dealt with is what to do with delays caused by customs procedures.

A rail operator should communicate the number of containers to be loaded and unloaded to the terminal operator at required moments. If information about specific containers is not available on time or incomplete, these container will not leave the container train. In practice this means that

- at RSC and RU should be informed by the operator about the number of containers to be loaded and unloaded at least 2 hours before arrival;
- at ECT the operator informs ECT about number of containers to be unloaded at least 4 hours before arrival and at least 14 hours before arrival in case of containers to be loaded;
- ECT will communicate containers with incomplete information (number, container id, full/empty , DG) to operator, RSC and RU 2 hours before arrival at RSC. Such containers are not treated at ECT, but are transferred to RSC.

This procedure will have a positive impact on the dynamic terminal slot.

Integral train scheduling

Given the influence of terminal operations it is logical to include terminal times in the train scheduling. In other words, a train schedule as given to the RU includes realistic terminal slots. If such a slot is not available, the RU will not get the requested train path and yard slot. In that case Keyrail will develop a new train schedule, after communication with RU and terminal operator. So, a terminal slot is linked with an operator.

Replanning process

Specific procedures have been developed describing what to do with trains not fulfilling ETA or ETD, both at yards and for cross border traffic. They are quite detailed and well documented in Keyrail (2007f).

Train information

As mentioned earlier, the Betuweroute crosses the national network of ProRail. This means that in its train scheduling Keyrail has to take care of the 'free paths' offered by ProRail. ProRail use a standard operating rule set (GOR) for the electronic delivery of information by operators. Keyrail uses the same train numbering system as ProRail (Keyrail 2007g).

4.3.2.6 Keyrail services to be contracted

Keyrail has to fulfil the requirements of Dutch and EU law. EU Directive 2001/14/EG describes which services Keyrail is obliged to offer to operators and which services can be requested from Keyrail. Keyrail has developed a Basic Access Package ('Basistoegangspakket') that contains all services an operator needs to run trains on Keyrail managed infrastructure. Each operator has the same conditions and non-discriminatory rights to use this basic package, also knowns as Delivery of Train path ('Levering treinpad').

In the design of this basic package, Keyrail's aim was to offer a standardized and uniform service. Standardization and uniformity enable optimal exchangeability of products and flexibility of the whole product matrix. This holds for train paths (speed, frequency, connectivity, use of process tracks, etc.) and planning (fixed schedule, use of time windows, etc.). In this way the Betuweroute is used efficienty and planning becomes more predictable and certain.

Basic Access Package

The basic, non-discriminatory, package is required by EU law. It consists of the planning and delivery of train paths, which enable an operator to run a train from A to B in a specific time frame. A contracted train path is an agreement about running a train, including guaranteed options to use the capacity of process and yard tracks for arrival and departure including agreed process times. Keyrail guarantees the following (Keyrail, 2007a):

1. Connectivity;
2. Number of non-commercial stops;
3. Time window before departure

Ad 1. Connectivity

Keyrail guarantees

- to a terminal: connections between this terminal and the next terminal based on to be agreed staying times at terminals and waiting tracks;
- on the mixed network: scheduled arrival time with a margin of 3 minutes if the train departs within the agreed time window;
- on the German network: scheduled arrival time with a margin of 3 minutes if the train departs within the agreed time window.

This guarantee can only be kept if the train departs within the time window, if there is enough locomotive power and if the train driver keeps to the time schedule of the train path.

Ad 2. Number of non-commercial stops

In principle there will be no non-commercial stops on the Port line and the A15-trajectory, but they are not excluded, as the following shows:

- Port line: stops are quite likely due to openings of the three bridges (Suurhoff-, Caland- and Botlek bridge) and cross-over of tracks at yards (‘overkruizen’ in case of departure to the east and driving to the western part). The train scheduling allows flexibility to take care of such events.

On the A15-trajectory there is a limited chance for non-commercial stops to occur. Main causes are

- in- and outflowing trains at Meteren and Elst, where trains from the Betuweroute may conflict with trains on the Den Bosch-Utrecht and Nijmegen-Arnhem (passenger) trains;
- at Kijfhoek: direction west, potential conflict with trains coming from Dordrecht;
- stop at Zevenaar-Oost: potential conflict with in- and outflow of freight trains on the Arnhem-Emmerich route;
- technical stop 1: ETCS-equipped locomotives have to switch from ETCS-ATB to ETCS-PZB and v.v. at Emmerich. This so-called level transition takes 1 minute;
- technical stop 2: Trains coming from Germany have to call-in at Zevenaar-Oost to activate GSM-R (only western direction) (Sandt, 2008).

Keyrail distinguishes three kinds of train paths:

- a train path matching with the basic hourly pattern (Basisuurpatroon: BUP, ProRail) of the national network or the Stundentakt of DB Netz.
- a locomotive path for single locomotives or locomotives ‘transported’ in another train (‘opzending’)
- a local traffic path for the Maasvlakte-Kijfhoek section. This enables operators to optimise their logistic processes.

Ad 3. Time window before departure

For each train path, Keyrail uses a time window, which includes a departure moment and a margin to leave earlier (‘vertrekvroeg’) or later (‘vertreklaat’). The whole time window is 15 minutes (5 minutes later – minutes earlier). Figure 5 gives an example with two cases (‘Situatie 1’ and ‘Situatie 2’).

If there is no overlap with the time window of the next train, an ‘acceptance’ is given. Late departure are accepted if Traffic Management (VL) agrees, if the loc(omotive) has enough traction power and if there is no overlap with the next time window. Keyrail may guarantee an early departure.

Keyrail will develop up to four time windows:

- two for the A15-trajectory: heavy and average;
- two for the Port line: heavy and single locomotive.

These time windows are independent of the route or the location of departure.

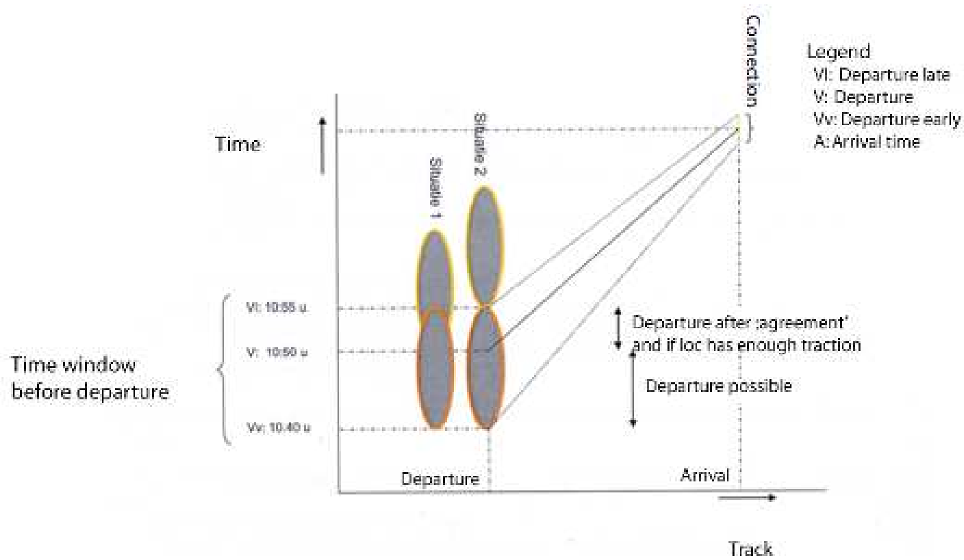


Figure 5. Departure time window

Source: Keyrail, 2007a.

A train driver may use process tracks at yards, provided his train stays there at most 90 minutes before arrival and 120 minutes before departure. Container shuttles running between different terminals in the Rotterdam Port only have 60 minutes before arrival or departure. For unit cargo a departure may be extended to at most 180 minutes. This enables marshalling and other tasks to be elaborated.

If a train departs earlier from a terminal and because of this parks longer on process tracks, Keyrail allows this if space is available and the processes of other operators are not compromised.

In future, a more diversified product offer may be launched by Keyrail, such as slow lanes or priority lanes, rush- and non-rush hour paths.

Next to this Basic Access Package, Keyrail offers

- access to services

- additional services
- supporting services

Package 2: Access to services

An operator can use the following services from Keyrail:

- access to electrical power
- access to diesel tanking stations
- access to marshalling yards (process, parking and hire tracks) and load/unload tracks

Keyrail has made an inventory (reference situation or ‘nul-meting’) of the use of the Port line. It makes a distinction between ‘served’ and ‘non-served’ areas. Non-served areas are parts of the infrastructure where wagons are waiting for maintenance or are parked. It turned out that customers parked wagons everywhere they liked. At several places irregular maintenance activities were carried out, which could cause (serious) pollution.

A parking regime was introduced to improve capacity management and reduce environmental damage. According to this regime some tracks are reserved for maintenance, while on the other tracks this is no longer allowed. Operators are allowed to maintain and prepare their locomotives and rolling stocks, provided they follow specific guidelines. This is for instance the case at Rotterdam-IJsselmonde, where Shunter Rail is based. If an operator does not fulfill the requirements, he will get a warning and has to pay to neutralize the damage.

Operators are given access to these tracks for a predefined period of time. If an operator uses these tracks for a longer period (so-called ‘overstand’), he has to pay.

This stricter management of assets also facilitates maintenance of the infrastructure.

Package 3: Additional services

An operator may use additional services not provided in the other product packages:

- delivery of electrical energy. Keyrail does not offer this, but she can buy it for the operator;
- delivery of Diesel fuel. Keyrail does not offer this services, but is researching demand
- maintenance services (water, sewage, pressurized air, electric power) at yards. Keyrail offers them as part of its transport services, but not separately
- use of parking and hire tracks
- exceptional traffic and specialised scheduling related with it
- other specific transport for special transport (like chlorine trains)
- additional ICT entries

Package 4: Supporting services

Keyrail offers services for

- telecommunication (Mobirail GSM-R non safety-related services)
- tailormade ICT products like special train schedules etc.
- technical checks: not offered

To improve the quality of Keyrail's services specific targets have been defined for 2008:

- reduce response time for train path requests. This reduces the time an operator is uncertain about whether the request will be granted or not;
- reduce the number of changes of scheduled train paths. A change is defined as a change of departure or arrival time of more than 15 minutes while the time window is not kept. Both Keyrail and operators can issue change requests. A lesser number of requests leads to a better use of capacity and a more stable planning and execution;
- a more disciplined departure process. This increases the certainty of delivery of the train path to the operator. To do this, an operator should confirm the path given by Keyrail, deliever the wagon list and communicate its readyness. Keyrail should deliver the train path on time (free signal). If these steps are not followed, the train path is treated as 'cancelled';
- to increase the chance that a scheduled connection is achieved. This holds for the border connections (ProRail and DB Netz AG). The cause of the delay should be found and the actor (Keyrail or operator) penalized. A special problem in this area are the so-called secondary delays, for which a procedure should be developed (Keyrail, 2007a).

4.3.2.7 Quality of services and assumed behaviour

Quality of service is determined by a number of parameters such as: attainment or loss of connection, time window before departure, number of non-commercial stops and average speed (Keyrail, 2007a). Table 7 explains the way Keyrail thinks about quality.

Between Keyrail and RUs so-called achievement contracts are signed. For the year 2008, achievements in the following areas have been agreed on:

- stick to the agreed response time for requests;
- reduce the number of changes of earlier accepted train paths;
- achieve a more disciplined departure proces;
- increase the number of connected trains.

Table 7. Quality according to Keyrail

Process from plan to connection	Quality criteria	Safeguarding quality by
Planning of train path	Stable and predictable planning with limited number of changes and cancellations	* Transparent process for capacity distribution and response times * Agreements about changes and cancellations
Delivery of train path	Train departs according to schedule	* Transparent process before departure; * Actively managed departure process including consequences in case of non-performance
Attainment of connection	Train gets connection according to schedule	* Actively managed connectivity, including consequences in case of non-performance

Improvements in these areas help to improve the basic quality of services. In particular, the capacity of the Betuweroute can be used better and RUs have more certainty about available trainpaths.
Special rulings have been made (‘Prestatieregelingen I-IV; see Keyrail, 2007a, p. 13-15). The ‘Prestatieregelingen’ have a measurable impact. Some 86% of all trains now catch their connection , with a margin of only 3 minutes both at the border and the main railway network (Keyrail, 2007g). A separate ruling was made for cancellations.

An issue is the quality of the rolling stock used by RUs. Keyrail will develop a monitoring system, which will check specific aspects of rolling stock, which may influence rail safety, tear and wear or stress on rail infrastructure. Keyrail is allowed to charge RUs if they cause damage. This includes damage due to spillage of fluids (following the ‘polluter pays principle’).

4.4 Summary

In this chapter we have decribed and analysed the technical and economic prerequisites for an efficient integration of the Betuweroute in the European rail network. These prerequisites are the following:

- Allowances for rolling stock, operations and staff. These should be transparent and fair;
- Interoperable railways. This involves removal or at least reduction of the many transnational technical barriers, more in particular between the Betuweroute and

Germany (as part of the Corridor A - Rotterdam-Emmerich-Genoa). The installation of 25 kV and ERTMS in the Netherlands is not yet followed by Germany. This is why multisystem locomotives will also be needed in future. At the moment, ERTMS is still not (always) functioning as expected;

- Optimal train scheduling. Keyrail has developed an innovative schedule for train path planning, consisting of several layers, each having a dedicated system with transparent rules for capacity requests and division of capacity among requestees;
- Corridor management. Until recently, train management was a national (or even regional) activity. The introduction of corridor management on the Betuweroute means a major step forward in this area. The project Ketenregie will ultimately make it possible to match demand and capacity for train paths in a much more optimal way. It means that running and parking tracks and terminal tracks are integrated into one information system, open to all relevant stakeholders. It requires all stakeholders to co-operate, acknowledge common interests and subsequent teamplaying behaviour including on-time transfer of required information when deploying trains on the Port Line;
- The use of economic incentives to motivate the RUs to use available rail capacity in a more optimal way. This includes train path pricing, tariffs for parking trains and other services offered by Keyrail.

5. Infrastructure maintenance innovations

5.1 Introduction

In this chapter we will describe an “innovative infrastructure maintenance concept optimizing maintenance costs, safety and operational availability of the Betuweroute.”

This chapter consists of the following. Section 5.2 compares the traditional maintenance practice with the innovative maintenance concept chosen for the Betuweroute. Section 5.3 discusses the main aims of the maintenance contract and the conditions of the contract. It is important to mention that OTB did not have access to the real contract, but only to the public documents used in the tender procedure. Then, section 5.4 discusses the maintenance to be carried out in more detail. Next, in section 5.5 the first results of the new way of carrying out maintenance on this new railway line are discussed.

5.2 Traditional and innovative maintenance

5.2.1 Asset management

In recent years, also given the billions of Euros spent each year on infrastructure, there is a tendency among infrastructure managers to regard infrastructure as an asset, hence the term asset management. This can be defined as “optimizing decisions on construction, management and use of physical objects to realize the desired functionality and quality required by stakeholders within given essential pre-conditions”. Asset management should contribute to (Railforum, 2005):

- better utilization of the available capacity, enabling rail traffic growth;
- higher quality of rail transport, attracting more customers;
- a safer working environment for maintenance operators;
- higher cost efficiency;
- a more professional railway sector.

5.2.2 Maintenance contract: concept and scope

The maintenance contract for the Betuweroute covers “daily preventive and corrective maintenance and related maintenance management exclusive lifecycle management of the Betuweroute.” (Keyrail, 2007i, p. 2) This will secure the timely availability of the Betuweroute for railway operators. The contract does not cover major renovation or renewal of the railway line. The latter is not the responsibility of Keyrail, but of ProRail, the Dutch national railway manager.

A key element in the maintenance contract is that Keyrail and the main contractor will follow a development trajectory, which aims to reduce costs, increase quality and optimise the availability of the rail infrastructure (Keyrail, 2007i). This development trajectory is also known as the Growth Model ('Groeimodel' in Dutch; Keyrail, 2007h). The idea is that Keyrail and maintenance subcontractors jointly work on optimisation of the Betuweroute by introducing improvements in the areas of technology (e.g, monitoring), regulation (e.g., reporting), processes (e.g., incident management) and scope of the contract (e.g. new services). This is also known as value-driven optimisation (Zoeteman, 2007).

5.2.3 Innovations

In a traditional setting, the railway manager and several maintenance contractors make project-wise agreements about maintenance, which is then carried out by these contractors and/or their subcontractors. The railway manager manages and monitors the maintenance works, while the contractors follow 'orders' from the railway manager. There are quality targets to safeguard the work done, but there is no guarantee that these targets are also met and maintained in practice. A key issue here is that the relations between the commisioner and the contractors are rather informal and agreements have an implicit nature. Experience shows, that the real availability of infrastructure and quality level of the infrastructure can be (much) less than the levels which are regarded as acceptible. By its negative impact on availability this will also have a negative impact on the commercial exploitation of the Betuweroute and on railway safety.

The aim of Keyrail is to counteract the latter situation as much as possible. This is done by treating maintenance in a different way, called condition-dependent maintenance and management (Keyrail, 2007j). This means that maintenance will be carried out at the moment when it is necessary (not more and not less), taking proper care of applicable law and regulations.

A balance has to be found between the traditional contract sitatuation and intensive co-operation between maintenance company and manager of the infrastructure. The new way of co-operation can be called 'steering on ouput' (Zoeteman, 2007). It assumes the following:

- transparency in the relation between activities, costs and output (A)
- knowledge of the interaction between the output of the asset manager and RUs (B)
- knowledge of the long-term effects of maintenance (life cycle management; LCM) (C)
- structures and systems to use the information provided by A-C swiftly and effectively.

Transparent information about the quality (by Key Performance Indicators; KPI's, see section

5.9) and quantity of the infrastructure is a conditio sine qua non. Measurement data from all applicable sources will be used to analyse the work carried out by the maintenance company and the expenses made by this company.

The number of main maintenance companies was limited to one or two, responsible for all regular maintenance for a 3-year period (1.1-2008 until 31-12-2010, which an option for an extension until 1-1-2013). The period chosen allows the main contractor to invest in the development of a dedicated maintenance program. The main contractor and Keyrail also have a different relation, instead of being commissioner and provider, both are partners. The main contractor does not receive ‘orders’, but is supposed to manage the maintenance works itself. Keyrail will only monitor whether the agreed quality targets are reached and maintained. It is up to the main contractor to decide which maintenance activities have to be carried out and when in order to secure the agreed KPI’s. Results of maintenance become better measurable and hopefully also better manageable.

Part of the available train capacity is explicitly reserved for maintenance. In this period no normal railway operations are possible. The hope is that the maintenance contract makes maintenance more predictable. This in turn makes it easier to manage available capacity for normal railway operations, thereby also reducing the need for discussions (or conflicts) among stakeholders about available capacity, as happen regularly on ProRails’ rail network.

Keyrail’s aim is to develop a common philosophy with the maintenance company on how to carry out maintenance and to continuously improve the price-quality ratio of asset management and maintenance. Chain management is regarded as the key to optimise maintenance costs. Options in this area are division of maintenance work during day versus night, optimal use of the infrastructure and clustering of activities etc. The maintenance company will act as coordinator for the activities of specialized subcontractors.

5.3 Aims and terms of the contract

Following European legislation, an open European tender was carried out in which five companies participated. The contract was given to a company, which fulfilled a list of criteria, including 1. nationality (management and staff should master the Dutch language), 2. economic and financial viability, 3. technical and organisational experience with projects of comparable size and budget, 4. experience with maintenance management [6], 5. qualifications, most notably quality management with ISO certification and integral quality

[6] Keyrail (1007j) distinguishes between a. maintenance operations (periodic and corrective), b. maintenance management (focus on efficiency), c. installation management (focus on effectiveness of maintenance) and life-cycle management (focus on RAMSHEQ and costs). Stage a. is the lowest and stage d. is the highest stage of maintenance.

plan and compliance with Dutch regulation, and 6. future potential related with the earlier mentioned quality improvement trajectory (Keyrail, 2007i, j).

The work to be carried out has an estimated yearly value of 5 million Euros. It involves (supervision of) maintenance of

- 100 kms main track, 180 kms secundary track
- 150 main track switches, 600 secundary track switches
- 125 ha vegatation, 15 kms of canals 5 ha of road, 30 kms of fences and 20 kms of sound barriers
- road crossings, viaducts, civil constructions etc.
- energy supply and electrotechnical installations for 25 kV, 10 kV, 3 kV and 1500 V DC power supply and its supervision (SCADA)
- telecommunication cables
- rail-related buildings
- (2008 only) ATB-NG, Jade cricuits and 600 signals
- preventive and corrective track stabilisation (in all planes)
- operational ownership: access management, dealing with complaints, monitoring of subcontractors
- preventive and corrective maintenance of ERTMS, 25 kV, voltage sluices and TTI (Tunnel Technical Installations, see section 9.4.1.1) during the warranty period will be carried out by their respective suppliers, but the main contractor is responsible for corrective management of failures. The main contractor organises a 24/7 organisational unit to take care of failure management
- not included in the contract are the tracks connecting shippers with the secundary or main tracks and the tracks on the premises or inside the buildings of shippers.

During the tendering process, potential contractors had several options. First, they could choose between an offer for the whole Betuweroute or for one of the two parts (A15 and Port line). Second, companies could choose to operate on their own or as a combination of firms.

Accepted [7] maintenance companies made their offer. Keyrail assessed each offer and made a final choice based on a list of criteria, which each gave a score in points. For each of the two parts of the contracts (A15 trajectory and Harbour line) a separation scoring was made. The economically most beneficial offer (EMVA in Dutch) was a weighted average of the offer

[7] Keyrail's criteria for 'accepted' maintenance companies are derived from those formulated by ProRail (2006, 2007b).

price (70%) and quality criteria (30%) Several combinations of offerings were possible (Keyrail, 2007j). Strukton B.V. had the highest EMVA-score and therefore won the tender and was later on also rewarded the contract.

5.4 Maintenance and asset management in more detail

5.4.1 Introduction

Maintenance and asset management refers to a set of the following tasks (Prorail, 2007b):

- functional condition maintenance (functiehandhaving in Dutch): work carried out to maintain a specified quality of all the infrastructure, buildings etc. This also includes co-ordination of the work carried out by subcontractors;
- functional repair maintenance (functieherstel in Dutch): repair of infrastructure to allow trains to run safely again;
- disturbance recovery: repair of infrastructure to the agreed quality level;
- maintenance inspections: systematic inspection of all possible defects that may become a threat to the agreed quality level of the infrastructure;
- operational asset management: maintenance of all non-rail infrastructure including access roads etc., in order to allow a viable use of the yards;
- maintenance management: systematic registration of all events related with rail infrastructure, systematic analysis of the status of the rail infrastructure, to implement improvements of the rail infrastructure and internal processes of the contractor.

5.4.2 Typology of maintenance

Keyrail (2007j) distinguishes between small-scale and large-scale maintenance/renovation and replacement.

Periodic maintenance focuses on a complete system. It deals with periodic inspections, preventive maintenance, either situation-dependent (TAO or Toestand Afhankelijk Onderhoud in Dutch) or use-dependent (GAO of Gebruiksafhankelijk Onderhoud in Dutch). Then there is corrective maintenance and disturbance-dependant maintenance (SAO or Storing Afhankelijk Onderhoud in Dutch). All these activities are completely covered by the contract between Keyrail and its maintenance subcontractors.

Large-scale maintenance or renovation focuses (mainly) on components with a long life. As such, they need limited or no maintenance. When they are near their end of life, they will in most cases be replaced by new, similar components. Activities in this area are only for a small extent part of this contract. To be mentioned are replacement of frogs and tongues (most stressed parts of switches). For other activities, additional orders can be given or other subcontractors can carry out this work.

Replacement of parts that do not fulfill the requirements may also include function changes. Replacement is not part of the contract, hence in most cases additional contracts will be used to carry out this work. A replacement plan for the period 2008-2012 can be found in Annex 18 of Keyrail 2007j.

5.4.3 Basics of condition maintenance

According to Keyrail, condition maintenance demands the following:

- a reliable registration of the objects to be maintained
- reliable inspection- and measurement data of the actual situation
- condition warranty concepts for the different infrastructure systems

At the start of the contract, some of these data were not available. According to the contract, the main contractor will collect the missing data in the first six months of the contract and transfer them to Keyrail.

Maintenance should be carried out in such a way that the Betuweroute can be used in a safe way (required by law), that the railway line is sufficiently available in a reliable way, while the costs for maintenance are sustainably low.

OHP

ProRails' existing maintenance concepts are used as a reference. Where necessary, specific, location-dependent, diversions of these concepts will be used.
The main contractor will develop a maintenance plan (Onderhoudsplan or OHP in Dutch), which mentions in quantitative terms the necessary maintenance frequencies for single or clusters of specific infrastructure parts.

IHC

The OHP refers to the condition concept (IHC or Instandhoudingsconcept in Dutch), which contains reference values. If a (cluster of) part(s) is considered to no longer fulfill a set of reference values, then the part or cluster of parts should either be repaired or replaced. The IHC also mentions the necessary follow-up activities. One OHP has a life of six years.
The main contractor makes an assessment of the available inspection and measurement

data and initiates appropriate actions, including direct intervention, in case of a situation with an immediate deteriorating impact on safety and/or availability of the Betuweroute.

Work plan

The OHP is translated into a Work Plan (Werkplan in Dutch), which tells when and where which kind of maintenance will be carried out. The Work Plan will be discussed beforehand with Keyrail, who puts the workplan in action each year. The Work Plan also contains the (preventive) reconditioning and corrective maintenance activities accepted by Keyrail.

IHC, maintenance plan, work plan in more detail

The IHC is a very important instrument. For each subsystem, it describes separate functions and the foreseeable ways of failure.

A risk analysis will be carried out, starting with the whole system, ways of failure, causes of failure, and conditions of failure. Where appropriate, a technical decomposition of the system will be made, describing specific parts of the system. Then, specfic solutions, with their suppliers will be mentioned.

The analysis is complete with the inclusion of an indication of the chance of failure and its impact on the system. The service life of the system or part (standtijd in Dutch) is also mentioned following the appropriate data sheet from its producer and/or experience of the main contractor in case of parts with sufficient experience.

The impact of the failure will be described in terms of RAMS (reliable, available, sustainable and safe):

- R and A will be managed mainly by periodic maintenance based on TAO and GAO, also called small-scale maintenance (Klein Onderhoud or KO in Dutch)
- M refers to maintenance activities with no (direct) impact on RA. However, if not carried out, the life of the system is reduced, demanding a more rapid replacement of the whole system and large costs, and most likely also large-scale non-availability of the Betuweroute. Maintenance in this area is also known as large-scale maintenance (Groot Onderhoud or GO in Dutch)
- S refers to safety of trains and work force on, nearby or in the environment of the railway line. Failure of the infrastructure may create risks for railway maintenance workers.

An IHC is used to manage these risks for each infrastructure part, using previous experience of existing systems. For new systems, the documentation of their suppliers will be used as a main reference.

Risk management can be divided into strategy, action, interval (GAO), inspection interval (TAO), function test FT and follow-up activity in case of TAO or FT. Each interval is described in such a way that the maintenance actions can be clearly distinguished.
Finally, the IHC specifications contain a lower value, used as a reference voor (preventive) repairs. If possible, the specifications also contain safety values in case of safety risks.

Risk management demands quantitative data. In case of chance of failure and its impact, an indicative value is all that is possible at the moment. A valid weighing of these data is not possible, yet. With more years of experience, it may become possible to get a more complete FMECA (Failure mode and effect criticality analysis). This is also true for costs.

5.4.4 Basics of corrective maintenance

The aim of corrective maintenance is to reduce non-availability to the lowest possible level while maintaining the reliability of the infrastructure.
The main contractor will carry out at least the following activities in order to comply with the demands regarding corrective maintenance:

- to respond swiftly in case of disturbances. This includes communication with the SMC, Keyrail and subcontractors
- to have a 24/7 telephone center accessible for those parties who request maintenance
- to carry out all corrective maintenance work in the agreed timeframe (Functiehersteltijd in Dutch)
- to coordinate work of subcontractors in areas impacted by or having an impact on the primary maintenance area (or cause)
- to collect disturbance data from subcontractor and transfer them (electronically) to Keyrail, who will enter them in its irregularity database (Onregelmatighedendatabase in Dutch)
- if necessary changes of configuration management
- to relate irregularities wot already known problems
- to evaluate the irregularities and suggest changes of management and maintenance, which will then be decided by Keyrail

Incidents will be handled following a specific Incident follow-up procedure (Incident afhandelingsprocedure in Dutch). SMC Rotterdam will collect all calls about irregularities, relay them to the main contractor, who will then select an appropriate subcontractor to resolve the problems.

5.5 Incident and problem management

In case of incidents/disturbances, more in particular when a field specialist needs support, the following options are described in Keyrail (2007j):

- functional escalation; engineering back-up for operational workforce, in order to reduce stand-still
- hierarchical escalation: management back-up of operational workforce and relay of this information to Keyrail.

Incident management is related with performance management. The maintenance contract contains specific requirements regarding call time, response time, estimated maintenance time (minutes/hours), and the differences between the estimations and the time it actually takes to carry out these activities.

Problem management

Another important issue is problem management, i.e. to analyse the deeper causes of irregularities: what are the real causes, are there trends etc.?

Problems are solved by suggestions for improvement including changes. The main contractor communicates his findings with Keyrails' maintenance specialist and follows his advises or demands.

5.6 Supporting activities

There is a number of activities and procedures vital for a proper functioning of maintenance. Apart from the already described activities, worth mentioning are configuration management and management of stocked parts and equipment.

5.6.1 Configuration management

The aim of this task is to make a description of all objects in such a way that management, condition maintenance, changes and functional repair maintenance can be carried out in a proper way. Object data at the level of parts is contained and checked in a database of Keyrail called Configuration Management Database (CMDB). Data include supplier data, serial numbers, location data and the relations between the different parts. Keyrail will supply the initial data to this database The main contractor is responsible for configuration management following the profile described by Keyrail. Changes to the objects will be entered in the CMDB within 5 working days. The main contractor will report regularly about configuration management.

5.6.2 Management of stocked parts, equipment etc.

Keyrail provides the first stock of replacement parts, while the main contractor is responsible for a proper management of the stock of these parts. This includes a parts plan based on an analysis of the causes of failures, hence the need to stock specific parts and the quantity of these parts and reorder frequency. Parts can be owned by the maintenance subcontractors or by Keyrail. Next to parts, this management also deals with tools, measurement equipment, additional equipment owned by Keyrail.

The main contractor is also responsible for all contacts with suppliers of parts and tools.

The aim of this kind of management is to achieve an optimum between what has to be reordered/contracted and what is in stock.

For critical and/or infrequently ordered parts Keyrail can use the Railstocklist of RailPro/Voestalpine.

The stock of replacement parts remains in the ownership of Keyrail after the maintenance contract expires.

5.6.3 Operational tasks

The main contractor is responsible for the management of all non-rail infrastructure objects in the vicinity of the infrastructure. The contractor takes care of

- waste management
- removal of equipment, parts etc. where necessary to keep the areas tidy and clean
- prevention of damage to objects
- access control and key management
- complaints management
- safety and environmental issues
- third party access and refering them to Keyrail
- supervision of areas, yards and buildings
- information to people living nearby the infrastructure

5.7 Coordination and integration of maintenance activities

The main contractor coordinates and stimulates optimal co-operation among subcontractors and third party contractors in terms of time management, technically and in all other ways relevant for the maintenance activity, in particular in case of a non-availability of the rail infrastructure (Buitendienststelling in Dutch). Tasks include:

- coordination and integration of maintenance activities within the non-availability period
- decision about the necessary safety measures in communication with the subcontractor and in line with the requirements of the infrastructure system
- requesting a non-availability period
- if necessary supply of safety staff, documentation and tools.

Keyrail has the option of relieving the main contractor from this management task. This may happen in case of very large projects, in case of demobilisation, at the end of the contract etc. Keyrail may ask a third party to take care of this management task instead of the main contractor.

The main contractor will also take care of proper communication with other process contractors (PCAs) in the transition zones with other infrastructure managers.

5.8 Quality, safety and environmental management

5.8.1 Introduction

The main contractor has to fulfill the quality requirements of Keyrail for all activities described in the maintenance contract. Quality management is based on the quality system of the main contractor.

The main contractor has the following tasks;

- implementation and execution of quality management
- to prepare and work according to quality documents
- to execute tests of the system, processes and products
- to implement improvement measures
- to deal with and carry out corrections of deviations (cf. AVPOK rulings).

The main contractor makes a quality plan, which has to be accepted by Keyrail.

5.8.2 Safety management

Keyrail prioritizes safety and health. Safety management aims to warrant planned safety measures. The main contractor should follow all applicable laws and regulations. Regular safety analyses are part of the contract. Keyrail 2007j section 7.2 contains a complete description of all applicable laws and regulations and the safety analysis of processes and products.

5.8.3 Environmental management

The main contractor has to fulfill all applicable environmental regulations. Next to that, specific, addtional measures have to be taken, which are described in Keyrail 2007j section 7.3.

5.9 Key performance indicators (KPI)

5.9.1 Baseline

KPI’s (Keyrail, 2007h) are derived from Keyrail’s business aims. They describe the minimum targets (indicator values) to be realised by the maintenance subcontractors and the development of these targets in the future. They are predefined and can be measured in an unquestionable, transparent and objective way. Where possible, they should be derived from automated registrations of data.

KPI’s assume an active approach and management attention both by Keyrail and the maintenance subcontractors. There will be regular discussions about state-of-the-art and progress.

Targets should be set in a realistic way, based on past experience. However, because in case of the Betuweroute there is no past experience, these data will be generated by a ‘growing-in’ period (e.g. in the first year of the maintenance contract), after which the maintenance subcontractors and Keyrail will modify these targets (with the exception of safety inquiries and train free periods outside the maintenance scheduling OHR);

Targets which form the basis of KPI’s will as much as possible be derived from the design parameters (RAMS demands);

5.9.2 Aims of the KPI’s

KPI’s are determined in order to warrant transparency, joint securing of targets and swift modification.

KPI’s are meant to measure the performance of the maintenance subcontractors and a basis for improvements and monitoring of improved performances.

Learning should lead to better KPI values. Both Keyrail and the maintenance subcontractors aim to achieve these improvements.

For each KPI a measurement system will be installed, which periodically (monthly, quarterly) will measure the rea value of each KPI.

Each KPI will get a periodical target. This target should be realistic and be regarded as an improvement over the current situation.

Maintenance activities will be managed in such a way that the agreed KPIs will be realised.

Necessary improvement measures should be carried out. Both Keyrail and the maintenance subcontractors can propose such improvement measures.

Periodically an analysis of each KPI target will be carried out in order to see to what extent the target has been achieved.

5.10 State of the art

5.10.1 Introduction

The maintenance contract started on January 1, 2008. In the first half of 2008 regular maintenance should have started, but it became soon clear that there was a lot of repair work (‘warranty work’) to be done, because of several reasons. First, Prorail and its (sub)contractors had in some cases delivered a poor quality of infrastructure. Second, there was stealing of copper wires in and around the infrastructure, including power supply and signalling cables. Third, there was the interaction with the environment, e.g. birds causing short circuits in the power system.

Instead of devoting their resources to maintenance, both the maintenance subcontractors and Keyrail were busy bringing the infrastructure at the minimum level as specified in the maintenance contract. This repair work had a negative influence on the way the contract could be fulfilled by both parties in this part of year 2008. Next to that, the subcontractors were not ready to deliver the required quality of work.

5.10.2 Overview of issues to be solved

A brief overview of the repair work is the following:

- power supply failures
- track leveling problems
- safety system irregularities: Euromax disturbance of level crossings. The remainder is functioning better
- ERTMS functional issues (third party contract by ProRail)

A more general issue is that the maintenance philosophy of the Betuweline is much different from what everybody was used to. This implies a learning curve.

5.10.3 Contract fulfillment

A basic assumption in the maintenance contract is that the maintenance subcontractors supply Keyrail with the necessary information to evaluate performances and that Keyrail is also able to use the registrated data in the intended way(s). What Keyrail needs is to know the state of the infrastructure, (potential) deviations, causes of deviations and whether action is taken to cure these deviations?

Keyrail's internal registration is about adequate now.

Keyrail inspectors found deviations of what was agreed in the contract. Keyrail was also of the opinion that the registration by the maintenance subcontractors did not allow Keyrail to have a good overview of the real maintenance situation. The maintenance subcontractors should provide Keyrail with management information, not with raw data. The latter happened in the beginning of the contract. So, The maintenance subcontractors had to learn to filter maintenance information.

The maintenance philosophy of Keyrail is different from that of ProRail. Keyrail leaves decisions on when to do maintenance to the maintenance subcontractors, and it is up to them to decide when and how to carry out maintenance, as long as the targets of the maintenance contract are fulfilled. Inspection frequencies should be such that the maintenance subcontractors know when and how to do the maintenance.

This different maintenance philosophy should also be internalized by Keyrail itself. Because of the repair work, this internalization was postponed to some extent.

It is important that the acceptable starting values describing the status of the infrastructure should be determined together by Keyrail and ProRail. For some systems it was easy to determine these values, while for others this was not the case. It took a lot of time before Keyrail and ProRail agreed on these values.

When analyzing the contracts between ProRail and its subcontractors, many disclaimers were found. In practice this meant that subcontractors not fulfilling their obligations could deny (any) responsibility. Next, the repair costs had to be borne by Keyrail or ProRail.

Because of this process, the year 2008 is regarded as a learning year.

It is interesting to give an example for the A15-trajectory. The RAMS target for availability was set at 99,6%. In the first half year of 2008 the tunnel technical installations (TTI) were 94% of the time working properly. For other installations, availability was lower than 90%.

When starting, it turned out that the subcontractors delivered a poor quality, leading to an availability of 64%.

During the development of the infrastructure, external requirements were stiffened considerably. An exampe are the requirements from the fire fighting agency. They wanted a greater and reliable supply of water. Because of this Keyrail decided to widen canals, which in turn led to problems with dikes and repair work.

5.10.4 Where we are now

At the end of 2008 many issues have been resolved. This enabled a further growth in the number of trains. However, the case is far from being solved. Keyrail expects that the remaining problems will only be solved until the end of 2009. Many ‘child diseases’ and disclaimers have to be dealt with. It will take at least a year before the Betuweline is finally at the required starting level due to the number of repair issues, the discussion about the causes, the disclaimers, the discussion about the best solutions, the available capacity of subcontractors and how to integrate them into the OHR.

In the second half of 2008 partners started working according to the maintenance contract.
Some contract sections were not fully operational. In the second half of 2009 more can be said about the real impact of the maintenance contract on availability and costs of maintaince of the infrastructure.
Regular maintenance will be fully operational in 2010.

5.11 Summary

The infrastructure maintenance concept of the Betuweroute is innovative when compared with conventional maintenance practices. This follows from the following:

- railway infrastructure is treated as an asset, hence the term asset management;
- maintenance is not contracted in the conventional way, where one party gives orders to another party, but infrastructure manager and main contractor are partners, cooperating in order to keep the quality of the infrastructure at the required level;
- the main contractor is responsible for maintenance of the infrastructure, deciding when and how maintenance is carried out, based on agreed quality standards (KPIs). This is called steering on output. This assumes transparency with respect to information about quality, maintenance activities, costs and benefits of maintenance;
- the maintenance contractor is responsible for coordination and integration of maintenance activities. Maintenance relates to periodic maintenance and to a very small extent also renovation;
- there is a long list of other activities of the maintenance contractor, including incident and problem management, supporting activities like configuration management, management of stocked parts and equipment, operational tasks like waste management and security.

Next to these activities, the main contractor is also responsible for quality, safety and environmental management.

Looking back at the first experiences with maintenance contracting, it became clear that there was a major problem: the railway infrastructure did not fulfill the assumed starting requirements, indicating that ProRail made soft contracts, allowing subcontractors to carry out their work as they liked, without repercussions in case of nonfulfilment.

As a consequence, it took a long time before most of the infrastructure issues were solved.

Next to this, both Keyrail and Strukton, the main contractor, had to get used to the new way of doing business. Information systems had to be developed and maintained. Procedures had to be developed and followed. This is all part of a learning curve.

Then there are the higher external requirements, for instance in fires, much higher standards had to be attained, leading to a longer delay before the railway line could be opened for traffic.

Since the second half of 2008 Keyrail and Strukton are working according to the maintenance contract, but not all sections of the contract are fully operational.

Keyrail expects that the remaining problems will be solved until the end of 2009. Then more information will become available about the real impact of the innovative maintenance concept. Regular maintenance will be fully operational in 2010.

6. Long freight trains and the Betuweroute

6.1 Introduction

In Europe, conventional intermodal freight trains have a length of at most 500-600 meters. Longer (up to 1000 meters) freight trains are uncommon in many countries. An exception is the Tallinn-Moscow container service (57 wagons/80-90 TEU/about 950 meters; WorldCargo News Online, 2008), but this train follows a corridor, which is scarcely used by regular passenger services.

Elsewhere, especially in the USA, Canada and Australia, very long freight trains (up to 2 miles in length - Wronsky, 2008) are in regular use, especially for trains with double stack containers.

In this chapter, we will analyse the following:

"Optimized train parameters on the Betuwelijn: Describe the restraints currently imposed by the Betuwelijn infrastructure for driving long freight trains (1.000 to 1.500m) and analyze the modifications needed for alleviating these limitation."

6.2 Train length - testing

There are important reasons why longer freight trains are uncommon in Europe. Key issues are technical constraints and commercial/logistics requirements (Janic, forthcoming). The recent interest in such trains is related with the growth in traffic, which asks for higher frequencies and/or longer trains. An example of the latter is the foreseen increase in weight of coal trains from the 5130 to 5700 tons. Transport of coal is a growing market due to the closure of German coal mines and growing demand (RDE/KV, 2008).

The interest in longer trains leads to calls for experiments. In these experiments, the technical [8], operational and business-economic conditions of employing longer trains are studied. Such tests serve both the infrastructure manager and the RUs.

Two recent tests are worth mentioning. First is the test carried out between the yard of Maschen near Hamburg in Germany and Ringsted in Denmark. An RDE test train with a total

[8] UIC rulings mention a maximum trains length of 750 meters for trains equipped with mechanical brakes. Freight trains do not have a uniform composition, take more time to reach a given speed and react relatively slow to braking commands compared to passenger trains. The longer this takes, the longer the separation time between subsequent trains. This has its impact on the way train paths can be used.

train length (incl. locomotives) of 835 meters ran in 2008. A second RDE test train ran on the Betuweroute. It had a train length of 1000 meters and ran from Rotterdam to Oberhausen in Germany, as part of the German Ministries of Economic Affair GZ1000 programme. Containers from Hupac and ICF were shipped. Traction was provided by a single BR 189 class locomotive. According to Keyrail, longer trains reduce traction and personnel costs for its customers and reduce CO_2-emissions. Next to improving productivity of rail freight transport, longer trains can also provide space for more trains, provided that available bypass sections are extended and the signalling system is adapted to longer trains (Keyrail, 2008e).

The impact of longer trains on ETCS/ERTMS is still studied. ERTMS was *not* developed with the typical freight train parameters in mind, but for (high-speed) passenger lines (Klomp et al., 2007a). UIC is still studying the issue of eventual modifications to the ERTMS specification. On the Betuweroute, the recent test showed that longer trains are compatible with ERTMS.

In Germany, RDE plans a test with trains of 1500 meters. According to RDE there are no foreseeable technical problems on the foreseen trajectory (Korridor 4G or right side Rhine Valley-route, part of the Rotterdam-Genoa freight corridor). This includes the signalling system. The test should also include the Betuweroute, altough this plan is not communicated with Keyrail, yet.

This Rhine Valley trajectory is already mainly used by freight trains (passenger services use the left side of the Rhine). If longer freight trains should become standard on other parts of the German network, especially were mixed traffic is common, large investments are inevitable (RDE/KV, 2008).

6.3 Dealing with restraints on The Betuweroute

On the Betuweroute there are several constraints which may prohibit the use of longer trains:

- The maximum allowable train length of freight trains is 700 meters on main lines in the Netherlands. On the Betuweroute 750 meters is allowed. On other railway lines where tracks are shared with passenger trains, platforms only allow train lengths of at most 415 meters. This means that if long freight trains have to wait in passenger stations they may block part of a station. In case of the Betuweroute this is not an issue, because there are no passenger stations along this line.
- Longer trains are only accepted with a permit for Exceptional Transport. Train length should in any case match the length of available tracks and the existing train scheduling

plan.

- A potential constraint is the length of the voltage changeovers (sluices) between the 1500 V DC and 25 kV AC powered sections. If such a section is shorter than the intended train length, its wheels could cause a non-intended connection between the two power systems. A similar train may also create a problem with train detection in conventional signalling systems. Tests carried out at the short connecting curves at Meteren and Elst have revealed that technically they are safe to be used by trains now (Keyrail, 2008g).This offers interesting north and south-bound connections for RUs.
- Axle counters may need adaptation. Is it possible to develop a dynamic counting system?
- What to do with tunnels having a safety system based on standard train lengths?
- The use of longer trains also demands the use of more or more powerful locomotives, so there is an investment need. However, this investment need was already present because of the transition from 1500 V DC to 25 kV AC.
- What will be the impact of longer trains on the scheduling of maintenance? Because of safety reasons, maintenance is increasingly carried out during night hours in the Netherlands, because passenger services are either absent or run with a very low frequency in this part of the day. Suppose that long trains would be allowed during night hours, is there still time available for maintenance?
- What to do in case of accidents? Where to park such long trains? If they can only be parked at process tracks, they block running trains.
- Is there sufficient and stable demand for such long trains?

In sum, there is a long list of advantages and disadvantages of using longer trains (see Table 8).

The use of longer trains was not a design criterium for the Betuweroute. At a late moment a decision was made to make a reservation to enable future use of double stack trains. Transport of containers in two layers increases economic payload. In the US, where diesel powered locomotives dominate freight transport, this implementation helped to improve the competitive edge of railways in a major way. In Europe, running double stack trains is halted by the commonly available overhead powerlines and its impact on the so-called ‘free profile’ of the infrastructure. It would also demand the use of different container wagons than we have now in Europe. Rails with a higher strength would also be needed if these wagons have an axle load above the current limits.

Table 8. Some (potential) ad- and disadvantages of longer trains

(Potential) advantages	(Potential) disadvantages
Cost effectiveness; improved competitiveness vis-à-vis other modes?	Investment costs: more or more powerful locomotives are needed
Improved utilization of network	Manoeuvrability issues: e.g., longer duration of braking and stopping, tunnels and viaducts
	Safety issues related with multiple engine deployment (power distribution, braking and radiocontrol)
	Signalling issues: block length, detection
	Infrastructure: limited length of waiting, parking and process tracks; high investments in infrastructure needed to adapt
	In case of higher wear and tear: higher maintenance costs
	Conflicts with other trains, blocking of process tracks at stations and yards
	Additional shunting needed (splitting and hooking of trains) at stations and yards
	Conflicts with road/barge – trains blocking at-grade crossings and extending bridge opening closing times
	How to schedule such trains? If they run during the night hours, this may interfere with maintenance works

To enable double stack trains, the tunnels of the Betuweroute have been built much higher than needed for conventional container trains. It would have cost much more if they would had to be converted in future. Viaducts and other parts of the infrastructure can be more easily adapted, so these were built for standard height trains.

6.4 Summary

Long freight trains are uncommon in Europe, unlike the situation in the USA and Canada. In those countries, clear financial benefits have been demonstrated. In Europe, technical constraints, such as available track length and length of signalling blocks, and commercial/logistic requirements (lack of enough transport volume) prohibit deployment of such trains sofar.

Recently some tests with longer trains have been carried out in Europe, including a test with such a train on the Betuweroute. These tests were successful, showing the potential for longer trains, but at the same time also the limitations have become more clear, especially in terms of operational characteristics, in terms of conflicts with other trains and inefficient use of railway infrastructure.

7. Locomotives

7.1 Introduction

The success of the Betuweroute freight railway line depends on the availability of locomotives equipped with compatible technical installations. In this chapter, we will discuss the following task:

“Deduction of required equipment for the locomotives with respect to operation schemes and improved train parameters.”

7.2 Required information

In section 4.2 we have elaborated the issue of interoperability. From it, it follows that a successful attempt to use the Betuweroute assumes that each RA has the number of multi-system locomotives required to carry out its planned services.

In order to fulfil the research task, we should have access to company specific information including operation schemes per company, volume transported, etc. Experience has shown that this kind of information will not (easily) be released by the operators. What we would expect is information about investments in new rolling stock related with the conversion towards ERTMS (section 9.2) and 25 kV (section 9.3). RDE has prepared a report for the EU related with subsidization of ERTMS equipped locomotives. It is not released by its top management, despite many requests from OTB, including those issued during several Steering Committee meetings.

In the report written for workpackage DA 5.1 we have included a global description of a demonstration activity by KV, but it is difficult to generalize this towards other RUs.

What we will do next to that is to give an indication of the estimated costs of upgrading per locomotive. We will restrict ourselves to ERTMS upgrades (section 7.3). Next (in section 7.4), we will discuss the issue of locomotive availability.

7.3 Costs of ERTMS locomotive upgrades

In a study for the Dutch government (Arcadis, 2007) the following estimates for ERTMS upgrades can be found. ERTMS Level 1 will cost Euro 92.000 for a new locomotive (ERTMS is then part of the specs) and Euro 203.000 for an upgrade of an existing locomotive (aftermarket solution). ERTMS Level 2 is more expensive: Euro 125.000 for a new locomotive and Euro 240.000 for an existing locomotive [9].

An example was given for the complete Dutch fleet of 1750 locomotives (100 already equipped with Level 2), ERTMS would cost at least Euro 250-455 mln. To these costs, one should add costs for upgrading of the infrastructure. These will be higher if Level 1 is chosen as an intermediate step instead of a direct migration to Level 2, because in the first instance two parallel systems have to be installed in the infrastructure, which also increases maintenance costs [10].

Migration towards ERTMS may take several decades, due to the very long (des)investment periods as used by railway companies.

7.4 Availability of locomotives

In order to use the Betuweroute, operators first have to make the choice to reroute their existing traffic, but they will only do so, if they have sufficient locomotives with an operational license for the Betuweroute. On top of that, user charges should be competitive with the charges paid for the use of the existing, conventional, Dutch railway lines.

Before RUs can use these locomotives, they have to buy them. But, then the suppliers of ERTMS equipment should be able to produce sufficient ERTMS units to the locomotive manufacturing industry and these units should be fully compatible with the track side ERTMS infrastructure.

When ordering locomotives, train operators will take care of several decision criteria (Pierick, 2008):

- contracted transport volume;
- cost add-up for locomotives equipped with ERTMS;
- employability of the locomotives. If companies also operate in the Belgian-French market, it makes lesser sense to buy locomotives with ERTMS onboard.

In the beginning, railway operators were hesitant to buy locomotives equipped with ERTMS. At the same time, suppliers of locomotives could not produce the required number of locomotives and/or ERTMS installations. The latter was due to the uncertain ERTMS

[9] These costs are probably a low estimate. If demand rises strongly, the few available suppliers are likely to increase their sales price.

[10] Arcadis mentions infrastructure costs of Euro 2.2-4.9 bln. for the complete Dutch signaling infrastructure, the variance depending on the level chosen.

development trajectory, with its inadequate standardization and time consuming licencing procedures.

Another issue was the time needed to train locomotive drivers and staff in learning ERTMS systems in practice.

Then there was the question whether the contracted trains could run in practice, because the train operator was not certain whether the requested train paths could also be contracted in practice. If not, it did not make sense to order additional locomotives.

The number of available and fully licensed locomotives will increase over time. In September 2008 50 locomotives supplied with ERTMS Level 2 equipment from Alstom were available. Siemens/Alstom have supplied trackside ERTMS equipment, which made track-train integration easier for Alstom than for supplier Bombardier. Bombardier hoped to have 30 locomotives licensed in December 2008. Locomotives licensed for Level 2 need an additional license for Level 1 in order to use the Port Line (Ministerie van Verkeer en Waterstaat, 2008). The commonly held belief that Level 1 is a subset of Level 2, hence the option of switching a locomotive easily between Levels 1 and 2, is not correct (oral information from Keyrail).

The issue of deployment of locomotives will be elaborated further in the DA 5.1 report.

7.5 Summary

The principal task of this chapter could not be (completely) fulfilled due to a lack of direct information sources.

We have decided to replace this task by a more realistic one, namely to describe the costs of installing ERTMS and the reasons why ERTMS-equipped locomotives entered service in the way they did. A more elaborate description of ERTMS deployment can be found in chapter 9.

8. User charges: train paths, parking and other

8.1 Introduction

The task for this section should have been the following:

“Deduction and recommendation of additional short time measures, general framework for train path pricing under consideration of envisaged models for funding of additional equipment on locos by the EC.”

References to locomotives, as far as we had access to the required information, can be found in chapter 7. Here we will discuss pricing of services. A relation with EU funding could not be established due to the lack of information.

Keyrail (2007a) makes a distinction between three product categories:

- train paths including Bonus-Malus and cancellation ruling
- use of yards for parking and for hire
- other products

8.2 Paying for train paths

Keyrail’s aim is to optimally use the existing infrastructure capacity. Users are charged according to the number of train kilometres. At the moment there is only a price differentation due to the type of train path and the moment of reservation of a train path.
The pricing mechanism stimulates early bookings (via a price cut) and penalizes late bookings (via a mark-up). This mark-up is not used for single locomotive and local traffic paths on the Port line in order to have enough flexibility.
The tariff will grow in the next years following this table:

Table 9. Basic user charges (actual and planned)

	2008	2009	2010	2011
Basis charge	€ 1,41	€ 1,69	€ 1,99	€ 2,33

Note: all charges including inflation.

A differentation is applicable depending on when the request is received:

Table 10. Charges per train type

Tariff (% of Basic charge)	**Standard pattern path**	**Single locomotive path**	**Local train traffic path**
Year Plan (+ changes)	90%	N.a.	
Day Plan > 30 days before departure	90%		
Day Plan < 30 days before departure	100%		
Traffic Management (VL)	120%	50%	100%

To reduce the number of changes and increase the number of connections Keyrail will monetize the quality rulings. The following schemes are foreseen as of April 1, 2008.

Table 11. Bonus-Malus ruling (rule II)

Phase in which changes occur	Charge to be paid
Change request phase	N.a.
Day Plan < 30 days before departure	€ 20 per change
Day Plan > 30 days before departure	€ 40 per change
VL (only if change of A/D station within Rotterdam port)	€ 40 per change

Table 12. Connection ruling (rule IV)

Blame on Keyrail	€ 50 per lost connection
Blame on RU	€ 50 per lost connection

To reduce the number of cancellations, the following scheme is put in place.

Table 13. Cancellation ruling

Phase in which changes occur	Cancellation costs as % of user charge
Change request phase – for the remainder of the year	0%
Change request phase – during 1 change request sheet period	10%
Day Plan < 30 days before departure	25%
Day Plan > 30 days before departure	50%
VL > 4 hours before departure	90%
VL < 4 hours before departure	100%

As mentioned in section 3.5, Keyrail employs a *volume strategy* due to existing technical constraints, which limit the use of the Betuweroute. The total amount to be paid by RUs for the use of train paths is limited, taking care of the abovementioned rulings. The following calculation is given:

Minimum amount to be paid:

* 95% x (total train kilometers for pattern paths x basic tariff 2008 * 100%)

* 95% x (total train kilometers for single locomotives x basic tariff 2008 * 50%)

* 95% x (total train kilometers for local traffic paths x basic tariff 2008 * 100%)

Maximum amount to be paid:

* 105% x (total train kilometers for pattern paths x basic tariff 2008 * 100%)

* 105% x (total train kilometers for single locomotives x basic tariff 2008 * 50%)

* 105% x (total train kilometers for local traffic paths x basic tariff 2008 * 100%)

For the period 2009-2011 a range of 90-110% is mentioned (most left part of the equation). The technical projects for the Betuweroute have not been completely finished. Due to this, the number of trains per hour is below the foreseen 8 trains/hour/direction. To achieve that target a number of things has to be realised and organised (see Table 14).

Table 14. Remaining technical issues to be solved

A15-trajectory	**Port line**
25 kV available for - double traction 5000 tons train weight - single traction 2400 tons train weight	25 kV available for - double traction 5000 tons train weight - single traction 2400 tons train weight
Extension of some curved track, voltage sluices and changeovers at the D/NL border (to allow 60 or 80 km/h)	ERTMS Level1 implemented and operational (no restrictions for shunting or capacity compared to accepted design)
Single and double track switch-off (incl. handheld terminal HHT)	
No restrictions for transport of dangerous goods due to insufficiently functioning infrastructure	

Because of these remaining issues, user charges are reduced (see Table 15).

Table 15. Malus (reduction of tariff) due to reduced availability

	2008	**2009**	**2010**	**2011**
Port line	10%	5%	7,5%	10%
A15		7,5%	7,5%	10%

This tariff reduction is applied over the complete bill paid by the customer.

8.3 Paying for parking

One of the aims of Keyrail is to make the Port area better accessible and improve the throughput of trains. This holds for the use of terminal tracks (discussed earlier) and other

tracks. In this way the available capacity is used in the most efficient way. Users of the tracks in the port area should be encouraged to change their behaviour and free capacity where possible. Capacity is scarce and should be used for primary processes (running trains) and not for parking trains or for (irregular) maintenance as far as possible. This also means that users have a limited time to use process tracks (staying time).
A charging system is employed to better manage the tracks (Table 16).

Table 16. Tariffs for the use of yards in Rotterdam Port

Use of tracks	Tariff
Process	Included in basic tariff
Process used for parking (parking tracks)	According to tariff table
For hire tracks	Ad hoc (tariff offer)

Many parameters are used in the final calculation (location, train length, centrally managed or non-centrally managed tracks). More details can be found in specific publications of Keyrail-OSS.

To enable the RUs to change their logistic practices, the tariff is reduced as follows (2008: 100%, 2009: 50%, 2010: 25%).

8.4 Paying for other products and services

Keyrail provides access to electricity and other services. Users are charged the real costs for the provision and use of such services.

8.5 Summary

In this chapter we have described the pricing system employed by Keyrail for the use of train paths, both for running and parking trains. This framework, and especially the clever use of bonus and malus incentives, should motive RUs to use the available railway infrastructure in the most optimal way.
A relation with EU funding models could not be established due to lack of information.

9. ERTMS implementation strategy

9.1 Introduction

In this section we will be describe the following task:

“ERTMS (European Rail Traffic Management System) implementation strategy for this part of the corridor.”

For decades, each European country developed its own railway system, tailored to regional and later national preferences. Cross-border transport was limited, and where it happened, a change of locomotives and staff at the border stations sufficed to continue the trip.
Since the nineteen nineties, legal reforms and subsidies by the EU stimulate open access to the transport market and standardization of the technical infrastructure.
In most European countries, new entrants have created vivid competition in the railway market, making serviceability a key orientation point for RUs. Customers do not accept long waiting times at borders or yards, which unnecessarily extend transport times, complicate logistics and lead to higher costs for the (final) customer.
In order to move goods from one country to another as efficient as possible, several key issues had to be solved. First to be mentioned is the creation of multinational railway operators, like Railion and Rail4Chem. Such bigger companies have the power to invest in new transport concepts tailored to the needs of their increasingly globalizing customers. They are also able to invest in new rolling stock, such as multi-system locomotives and wagons.
But also the role of infrastructure managers and governments needed adaptation.
These developments were an important step towards a European railway network.

In this section, we will elaborate one of most the profound standardization issues; the roll-out of a standardized (European) railway signalling system called ERTMS. We will also discuss the deployment of 25 KV, a new power supply system enhancing interoperability.

9.2 Conventional signalling systems and ERTMS

9.2.1 Conventional signalling systems

There are three different signalling systems (Van den Top, 2007):

- direction oriented (example: Automatic Warning System or AWS in the United Kingdom);

- speed oriented (example: ATB in the Netherlands);
- speed-distance oriented (example: ERTMS, LZB in Germany).

In case of AWS, if a train operator missed a non-green signal and does not slow down, he receives a visual indication on his cabin monitor and/or hears a sound warning him about this mistake. He then is supposed to reduce train speed. If he fails to do this, thereby making a second mistake, there is no automatic braking system correcting his mistake. In other words, AWS does not protect a train, but only warns its driver about operational mistakes made.

In a speed oriented signalling system, the main task of a train driver is to regulate train speed based on the speed advice ('goal speed') he receives from the signalling system. This assistant helps him to use a train path in the most efficient way. The driver also knows that the signalling system guarantees him that any train in front of him will be at a safe distance, allowing the train driver to continue his journey if he travels with the advised speed or stop if advised to do so.

Next to informing the train driver, the signalling system also supervises the way the train driver follows the speed advices. In case a driver, due to visual, interpretational or operational reasons does not follow the advised speed for a given rail section and this error would create a safety critical situation, the system can issue a non-voluntary braking command, thereby overruling the train driver (Van den Top, 2007).

This is the train protection function of a signalling system. Because of the automatic process involved, it is generally known as automatic train protection system or ATP.

The Dutch ATP system is called ATB ('Automatische Trein Beïnvloeding'). It is available on most of the Dutch railway infrastructure. When it was installed in the nineteen sixties through eighties two major decisions were made. First, at yards and stations where 40 km/hour or less was allowed do not have ATB code signalling nor overrule possibility, due to cost reasons. Of course there are lineside signals, but a train can pass a red signal (so-called SPAD or signal passed at danger or 'STS-passage' in Dutch) and still continue his journey, eventually colliding with another train. Next, ATB speed is limited to 140 km/hour. This means that conventional trains are restricted to 140 km/hour in the Netherlands. ATB is available in three version: ATB-EG on mainlines, ATB-NG on secondary lines (extended version with 0-140 km/hour protection and cabin signalling) and ATB+ (ATB-EG extension to allow the Thalys to run 160 km/hour on the 4-track Leyden-The Hague section).

In shunting yards a manual protection system may be installed, because operating conditions are different. Operating speeds are much lower (40 km/hour or less), hence safety is mainly related with the yard process. Local supervision or manual mode suffices.

We may conclude that ATB was an efficient *relatively* fail-safe system, but is has a number of known problems, which are likely to become worse in future, when traffic intensity continues to grow, both in terms of passenger and especially freight trains. This makes it inevitable to think about a more future-oriented signalling system. This is what the remainder of this chapter deals with, in a European context.

A speed-distance oriented signalling system is an extension of the speed oriented system, offering more information to the driver, allowing him to run his train in a more optimal way. Next to the maximum train speed, the available distance and inclination of the track are known up to the point where this speed is to be reached. The Information system combines these data with the train information (actual speed, actual location and brake capabilities of the train). Based on all this information, the system decides which is the major bottleneck, calculates the braking curve and advises a speed. Because this speed differs per train (type), it is logical to provide this information via a cabin terminal and not via lineside signalling. A speed-distance oriented signalling system is better known as ATP with brake curve protection and cabin signalling (Van den Top, 2007).

9.2.2 Why ERTMS?

Each country in Europe has its own railway signalling system. As a consequence of this, a train driver traveling through different countries must negotiate with different signalling regimes. For international services traditionally railway operators changed locomotives at border stations or other points where system or administrative differences [11] demanded so. Each stop meant an extension of trip time. Some optimization may occur, for instance if a train, instead of stopping at the country border, continues until the next main station or yard, but this demands locomotives equipped with multiple signalling and power supply systems, which are rather expensive.

Technically, it is also feasible to use these multi-system locomotives during a complete trip through several countries, covering hundreds or even thousands of kilometers. An example is the Thalys passenger service, which uses multiple onboard systems on its trip from Paris to Brussels/Amsterdam/Cologne. Such trains either do not have to stop at the system border or only for a very limited amount of time, while in other cases a lower speed passage is adequate in order to switch systems. Multiple onboard systems increase the purchase and maintenance costs of locomotives and increase the risk of technical interferences (Viaene, 2005). Change of staff will always be necessary, so a long distance service will always involve a certain number of (technical) stops.

[11] There was also a financial reason. It was easier to split revenues and costs if the national border was used instead of another point in the railway network.

With the introduction of ERTMS a new situation emerges. ERTMS or European Railway Traffic Management System is a combination of the European Train Control System (ETCS), communication system for railways GSM-R, the European Traffic Management Layer ETML (not developed yet) and the legislation and procedures for train use. ETCS is a signalling, control and train protection system. With ERTMS, the system (i.c. traffic management VL) knows the actual speed, train length and braking characteristics of all trains running in a specific corridor. The system provides the driver with dedicated information for his train via monitors in the cabin instead of via lineside signals or telephone. ERTMS is a movement management system. It supports the optimization of train operation, locomotive and wagon fleet management (RUs) and asset management (infrastructure managers).

In recent years, many European projects started to convert railway corridors equipped with conventional signalling systems into ERTMS managed corridors. Such corridors can be tailored to high speed trains, but also to mixed traffic (passengers and freight) or exclusively to goods transport like the Betuweroute.

ERTMS means that the existing, complex trackside installations will be partially replaced by flexible onboard systems. This will help to increase maintainability, reduce failures and lower costs in future (Van der Werff, 2007).

ERTMS, together with other technical development steps (such as those towards a uniform power system, the harmonization of procedures and technical admissions) is supposed to lead to one European railway network without technical obstacles for railway operators in the long run.

To summarize, the main benefits of ERTMS are the following (Wendel, 2007a):

- reduction of time for non-commercial stops (border waiting times);
- optimization of locomotives used in shuttle services, with shorter outage period;
- avoidance of multiple equipment in locomotive saves investment and operative costs (and also space);
- one standard technical acceptance and certification process for equipment, saving costs and redundancies;
- with one European train control system a bigger market is created, with lower prices for technology;
- co-ordinated ERTMS deployment will help to achieve scale economies in procurement of technical equipment and reduce deployment costs.

With standardized systems, trains can continue their trip and stop at a place more convenient from a commercial/logistic perspective.

As long as the complete European railway network is not converted, it is likely that the limited number of expensive locomotives equipped with ERTMS will be used as much as possible for relatively short hauls. This means that always an additional locomotive is needed for long distance trips. This is the experience from the BRAVO project. It may be concluded that the advantages of ERTMS are small in freight transport, at least at this stage of the ERTMS implementation. The most important benefit is the shorter trip time, where applicable. Next to that, most likely is a shift of the 'take-over' point (RDE/KV, 2008), but since ERTMS is not available in the western part of Germany, this benefit is related with the use of four-system locomotives (Series 189, a four system locomotive with ETCS version 2.3.0).

Factors that determine how and when ERTMS is introduced are in particular (SBB, 2007):
- the current level of safety techniques;
- the traffic intensity;
- the degree of rationalization of rail network;
- the proportion of cross-border movement;
- the financial situation in the country concerned.

9.3 ERTMS and 25 kV deployment

9.3.1 Europe

ERTMS is the result of negotiations between business and government experts. Standards are developed step by step and then translated by the industry into products. There is a development trajectory with a certain time frame, which in practice can hardly be shortened without consequences for quality and costs. Versions of ERTMS are being implemented, but none of them is completely without problems.

Conversion from conventional signalling systems towards ERTMS will take a few decades (probably by the year 2020 or even 2030) as both the infrastructure as well as the rolling stock have to be converted. Plans developed in Europe mention the introduction of ERTMS on new lines (mandatory) and next on other main lines, particularly if these have to be renovated and are part of an international corridor. CER (2006) mentions the year 2013 for the conversion of six corridors, including the Rotterrdam-Genoa corridor. Some 400 new locomotives with a ticket of 450-620 million Euros should be bought. Conversion of signalling infrastructure is very expensive, making it a multi-billion business. However, replacement was already inevitable, because many systems are nearing end-of-life. This, together with a multi-year introduction plan, eases the cost of implementation.

There are several Levels of ERTMS. The appendix to this chapter contains an explanation.

9.3.2 Standardization and national specifications

Interoperability requires that trains from whatever manufacturer should be able to use infrastructure equipped with ERTMS. Thus ERTMS infrastructure modules built by company X should co-operate with ERTMS modules in locomotives built by company Y. This co-operation is called train-track integration. It is complicated in several ways. First problem is that railway companies may have different uses of their trains. For instance, in situation S a locomotive series does not need shunting capabilities, so the functional specification (set of tasks) can be reduced. But, if in the opposite situation T an extension of a set of tasks is required or a special signalling regime is used in a country or at a yard, then the functional specification will be extended. This may lead to the development of different functional specifications within and particularly between RUs. Technical specifications are derived from these *local/national* functional specifications, which leads to different national implementations of ERTMS, which are the foundation of the STM modules of ERTMS.

Yet, the EVC computer [12] of a train should be able to communicate with different STMs (e.g., STM-ATB, STM-PZB) when running through a series of countries.

ERTMS norms are static, while national ATP systems have dynamic constraints. In order to create an open market for ETCS systems, it was necessary to make the STM independent from the EVC. In order to allow ‘foreign’ trains access to non-ETCS lines, European countries should develop an STM for their country [13]. In this way an open market would be created. Studies carried out by Alstom concluded that there was no norm for dynamic performance of trains. In some cases, even with static interoperability, no co-operation could be established between the EVC and STM modules from different suppliers. This is why Alstom developed the USSB (Universal STB safe box). This allows the national ATP system to remain unchanged, creating a de facto homologation of the STM. USSB emulates the behaviour of a STM, communicating the necessary function set (subset 035) with the EVC. The national ATP system can be switched on and off via EuroRadio/FFFIS messages and the EVC knows if the national system is working. Existing ATP can always be used as fall back mode. Easy migration to new versions of ERTMS is possible (Alstom, 2004).

In practice, incompatibility issues were less easy to solve, as will be discussed later.

[12] EVC = European Vital Computer, onboard automatic train control system. it supervises the movement of the train and sends information to the DMI of the train driver.

[13] Italy did not want to develop an STM, instead they dediced to convert the necessary number of locomotives to ERTMS Level 2 (Wendel, 2007a), which actually excludes the use of foreign locomotives (for the moment).

9.3.2.1 BEV21

A program called BEV21, in which ProRail and Alstom co-operated, can be regarded as the start of ERTMS in the Netherlands. It is part of the program BB21 ('signalling and traffic control for the 21st century or 'Beveiliging Beheersing 21'). The definition phase of BEV21 focused on customer requirement capture and analysis. Later an ERTMS Level 2 study was carried out, which included business cases. However, BEV21 was still running when engineers started developing ERTMS signalling specifications. This led to intensive and successful communication between the two development groups (Klomp et al., 2007a).

The main conclusions of BEV21 are as follows (Alstom, 2005):

- "all of the global signalling system's subsystems must be generic, and with their associated sub-system generic safety cases;
- The system, linked to the application, will remain specific. Indeed, all lines have their own specificities. It's much more efficient and simple to demonstrate the system safety within its application, instead of first implementing these specificities into a generic virtual track, demonstrating its safety on this generic track, and then demonstrating the conformity on the work performed on the real application with the generic track layout."
- Migration phase and STM: development and certification of a STM-ATB, very challenging project, because the STM concept wasn't all clear in 1999, a correct specification costed 2 year;
- In 2004: STM concept was not mature enough, both ERTMS (subset 026) and STM (subset 035) were static, but a dynamic version was needed, otherwise an STM-ATB would be bound to a specific type of EVC, while would violate the first aim of ERTMS, which is the opening of the signalling market. Instead, Alstom developed USSB to work together with ATB (homologated), fully compatible with their competitors' EVC.

BEV21 will realise the following (Van der Werff, 2007):

- application of ERTMS-based signalling systems;
- improved traffic control systems;
- renovation of interlockings (computerised interlocking machine: controls the position of switches: IXL);
- GSM-R implementation;
- 25 kV AC power supply for electrical locomotives.

ERTMS is a communication system, different from conventional ATP (Ceccarelli et al., 2008):

- conventional ATP: birectional communication between Centralized Traffic Control (CTC) and IXL, then transmission from IXL to ATP, next from ATP to trains;
- ERTMS: bi-directional communication between lineside ATP and the trains, the lineside ATP and IXL and between IXL and CTC.

So, with ERTMS all relevant trackside objects and the onboard unit (OBU) can communicate, either actively or passively.

9.3.3 The Rotterdam-Emmerich-(Genoa) corridor

9.3.3.1 ERTMS on the Betuweroute

In the Netherlands, ERTMS has been implemented on the Betuweroute, on part of the renovated Amsterdam-Utrecht mixed line, and on the HSL Amsterdam-Antwerp. The Netherlands have chosen to implement ERTMS Level 2, because Level 1 had only a limited value in comparison with existing ATB system and because a future migration from Level 2 to Level 3 is easier to implement. Level 3 is a longer term objective (Van der Werff, 2007).

The mainlines in the Netherlands are now equipped with ATB-EG. An exception is the dual ATB-EG/ATB+ installation on the Leyden-The Hague corridor. Secondary lines are equipped with ATB-NG and axle counters for train detection [14]. On the Betuweroute two sections still have ATB-EG and 1500 V DC: Barendrecht junction ('Vork') – Kijfhoek – Sophia tunnel and Zevenaar Oost – border – Emmerich: the ATB isles. In order to use these transition areas, a locomotive needs ATB-EG or STM-ATB modules onboard. A locomotive only equipped with ATB cannot use the A15 trajectory of the Betuweroute.

9.3.3.1.1 The Port line

Initially the plan was to use ERTMS Level 0 on the Port line. This turned out to have important negative safety consequences (ProRail, 2007a):

- in the Netherlands Level 0 is only allowed for trains running slower than 10 km/hour, but in other countries Level 0 allows a maximum speed of 100 or even 160 km/hour (in Switzerland). Introduction of Level 0 on the Port line would bear the risk that a (foreign) locomotive driver would drive with a too high speed at yards;
- trains running on the Port line frequently change composition due to marshalling (splitting and combining of trains). Keyrail traffic management (VL) needs up-to-date information about the composition of trains in order to properly guide a train. In Level

[14] Trains with ATB-EG are no longer allowed on such lines.

0 mode there is no check if a driver enters the necessary information into the system. After the necessary technical checks, he can start his journey even with improper information about his train. By using Level 1 SH a train driver is forced to stop in order to enter new train data and switch to “Staff Responsible mode”. Next, the train can change to “Full Supervision Mode”;

- with Level 0 the number of choices for drivers would increase, which would further complicate their use of ERTMS.

Because procedures alone are not enough to ensure the required safety-related behaviour, a decision was made to implement ERTMS Level 2 on the A15 trajectory and Level 1 shunting mode (Level 1 SH) on the Port line. All ATB infrastructure will disappear. Lineside signals will stay, because shunters use lineside signals for shunting. There is no radio block centre, so all information for the driver is going from the balises to cabin monitors. ERTMS will also be used for shunting, but there is no monitoring of braking curves. The removal of ATB will mean that, although they are not allowed to be there anymore, trains not equipped with ERTMS may run unmanaged over the Port line. A decentralised ERTMS system will be installed. This means inter alia that Kijfhoek VL cannot issue Temporary Speed Restrictions (TSRs) (Klomp et al., 2007a, b).

The decision in favour of Level 1 instead of Level 0 increases safety at a price: less flexibility (additional stop, shunting, some tracks cannot be used). Since the same procedure is also followed by through trains (fixed composition), such a stop could be a hindrance. A future upgrade could eventually remove this additional stop (ProRail, 2007a). Trains to and from RSC Maasvlakte can use the four kilometers long ‘Kortsluitroute’ in order to avoid the RSC Waalhaven (see Figure 6). This increases capacity and reduces trip time.

Why not Level 2 on the Port line?

Migration towards Level 2 was not possible yet because of several reasons (Ministerie van Verkeer en Waterstaat, 2007c):

- running trains on yards, and in particular shunting, is rather complicated, at least too complicated for existing ERTMS systems;
- migration from existing VPI interlocking [15] to ERTMS interlocking is very complex, comparable to a complete migration of Utrecht Central Station, the biggest station in

[15] “Interlocking is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks such as junctions or crossings. The signaling appliances and tracks are sometimes collectively referred to as an interlocking plant. An interlocking is designed so that it is impossible to give clear signals to trains unless the route to be used is proved to be safe.” (Wikipedia, 2008a)

the Netherlands;

- a network-wide, corridor-wise migration from VPI interlockings is carried out in a ProRail program called MISTRAL ('Migration Signalling Integral'), that started in the year 2000. This program was initiated to replace ageing (EOL< 2018) relay-based interlockings. Logic in relay-based interlockings was hardware-oriented, while in the new solid state interlockings the logic is software-oriented, which is updateable, hence future-oriented. In each replacement case a choice will be made between ERTMS-ready installations and full-ERTMS installation (Van der Werff, 2007). Some disinvestment in MISTRAL equipment and reconfiguration of ERTMS is necessary if at a later stage the ERTMS-ready installations have to be upgraded to full-ERTMS. Reconfiguration is necessary in order to optimize capacity. It is likely that because of the complexity of shunting and the use of radio guided locomotives existing shunting and departure lineside signals will stay. ERTMS Level 2 will then be installed as an overlay (Klomp et al., 2007a). MISTRAL is likely to reduce cost for interlockings by at least 30% (Van der Werff, 2007).

Figure 6. The bypass (lower curve) near the Waalhaven

Source: Keyrail, 2008g

9.3.3.1.2 ERTMS on the A15 trajectory

When planning ERTMS deployment, decision-makers were convinced that ERTMS was a grown-up technology. They choose the highest option available: Level 2. They did not want to invest in a fall-back mode with negative operational consequences (lower capacity in particular). Next to the EMC-related problems, this is another explanation why ATB-NG with lineside signalling and very large sections was not implemented on the A15-trajectory (RINA et al., 2007). Without a fall back mode, trains cannot run. Hence, until ERTMS was not fully deployed, tested and certified by a NOBO (Notified Body), commercial operations were halted.

On the A15 trajectory another complication exists. When leaving the Betuweroute, drivers first have to switch from ERTMS Level 2 to STM-ATB or ATB-EG. A few kilometers later they have to switch to the German PZB system and cross the Dutch-German border. From Germany to the Netherlands they first switch from PZB to ATB and then from ATB to ERTMS by calling in at a Radio Block Centre (RBC) (Sandt, 2008). These changes demand increased supervision by locomotive drivers.

Conversion to 25 kV [16]

The introduction of 25 kV on the Betuweroute has important consequences. First is the EMC (electro magnetical compatibility) issue:

- High-voltage AC creates noise on DC systems (1500 V DC);
- AC cannot be fed to DC powered locomotives – they will immediately switch off. This means that all linear extensions, crossing and parallel tracks and cable systems have to be shielded and isolated if they carry DC and AC respectively. By using power sluices the 1500 V DC and 25 kV AC sections are separated. This solution is difficult to implement at switches;
- 25 kV AC is even more lethal than 1500 V DC. Power lines need protective earthing. Conversion to AC high-voltage means that all objects near the railway line need protective earthing. This also reduces the risk of personal injury (lethal shock) for staff and unauthorized trespassers;
- The protective loop created for AC disturbes the GRS train detection as used in ATB, which also employs AC loops. ATB-GRS will be replaced by the Alstom-Jade track circuits.

A second problem is the operational complexity. A train powered by 25 kV AC has much more power than the same train powered by 1500 V DC. This is especially a problem with heavy trains going from a 25 kV section to a 1500 V DC section. Either additional locomotives are needed to use a train path as planned, or the number of path is reduced. An

[16] Source: Van den Berg (2008).

additional problem is that in the Sophia tunnel near Barendrecht mixed use of 1500 V DC and 25 kV AC was not possible.

The plan is to finish conversion of the power supply system of the whole Betuweroute around the year 2012. This would remove the 1500 V DC from the equation and the need for four-system locomotives, because after this step only 15 kV 16.7 Hz AC (in Germany) and 25 kV AC 50 Hz (in the Netherlands) would remain. Locomotives equipped with bi-courant AC power system are about 1 million Euros less expensive than multi-current locomotives having also DC systems on board. Until this conversion is finished, 1500 V DC will be used together with four-system locomotives on the Port line.

Completion of the 25 kV network could also help to replace the frequently used diesel traction by electric trains. This has operational benefits and is also better for the environment.

It is likely that the shunting hill and its tracks at Kijfhoek will not be converted, hence multi-current electrical locomotives or diesels are also needed in future.

Increasingly shuttles are used for direct services to and from terminals. Kijfhoek is now mainly used for single wagon transport and its capacity is used (far) below its maximum. An explosive (10-fold) growth of container transport is forecasted. This may lead to a conversion of Kijfhoek from a shunting yard into a buffer for trains and for long parking of wagons. This is n line with the project Ketenregie (see section 4.3.2.5).

Conversion of crossing sections of the A15 trajectory will also mean that the Dutch main line (passenger) trains crossing the Betuweroute have to be adapted for 25 kV AC.

The key choice was that conversion of technical systems should not have a negative influence on continuity. Because of this, a conversion process consisting of four phases was developed. Removal of existing systems was done after the new systems were installed and functioning flawlessly. In this way no unnecessary operational hindrance or safety gaps could emerge. A Big Bang (joint conversion towards 25 kV and ERTMS) is not possible. ERTMS is installed first and 3 months later works to install 25 kV can start. In this 3 month period the train detection systems are replaced (from GRS to Jade) and EMC conformity is tested (Pierick, 2008).

Due to the delayed availability of ERTMS Level 1 locomotives, the introduction of ERTMS and 25 kV was delayed substantially. The latest planning for the Port line is given in Table 17.

A special organisation, ‘Projectorganisatie Ombouw Havenspoorlijn’, oversees the conversion of the Port line.

Table 17. Conversion of ATB and power system on the Port line

Period	Maasvlakte-Pernis	Pernis-Barendrecht/ Waalhaven
25 kV		
Dec 14, 2008		Operational
Dec 12, 2009	Operational	
ATB		
Dec 14, 2008	In use until Level 1 is ready and reliable and Level 1 locomotives are available	Removed, temporary speed restriction
ERTMS		
End of June 2009	First Level 1 certified locomotives roll-in	First Level 1 certified locomotives roll-in
Oct 4, 2009	In use	In use

Source: Steenbeek, 2009; Ministerie van Verkeer en Waterstaat, 2008.

9.3.3.2 Zevenaar-Emmerich (Germany)

In Germany, PZB/Indusi is used on track sections which allow 160 km/hour. This includes freight trains. ERTMS is being implemented on some corridors. For the Emmerich-Basel (Switzerland) corridor, the following is aimed at (ERTMS, 2007a):

- “This is one of the prior lines in the German migration plan for the TSI Conventional Rail (German corridor concept for freight rail)
- It is a part of the Freight corridor Rotterdam – Milan/Genoa
- Equipped with ERTMS Level 2 overlapped to the intermittent PZB system and partly in parallel to linear LZB (for high-speed trains) ATP systems.
- The realization is planned in 3 steps from both borders to the inland.

It is planned to be in commercial operation for a first step by December 2012 and for the complete line by December 2015.“

DB Netz has decided to introduce ERTMS first on selected freight corridors and then on a selected high-speed corridors. Level 2 will be developed on its part of the Rotterdam-Genoa corridor as overlay (additional layer) next to the existing PZB system. This choice for dual signalling is based on the fact that otherwise a very large number of locomotives should have to be equipped with ERTMS. A dual signalling system has been rejected in the Netherlands (the MISTRAL modules are a necessary exception), because of the technical incompatibility issues described earlier, the doubling of costs and complexity and the fact that this provides no incentives for RUs to convert their rolling stock (Ministerie van Verkeer en Waterstaat, 2007c).

Technically a conversion into ERTMS is possible around 2012, but it is not clear whether this also holds for 25 kV AC. It is likely that the German 15 kV AC system is extended to Dutch territory (until the junction at Zevenaar Oost), thus replacing the 1500 V DC system. The compatibility of 1500 V DC and 15 kV AC has not been researched, however. This is critical, because it took 10 years to find acceptable solutions for the separation of 1500 V DC and 25 kV AC power systems (Van den Berg, 2008). Removal of the 1500 V DC bottlenecks increases the number of locomotives suitable for the Betuweroute and will also help to reduce border handling times (Wendel, 2007a).

Third track Zevenaar-Oberhausen

Following the Warnemünde Treaty between the Netherlands and Germany a third parallel track will be built between the Dutch border and Emmerich to significantly increase capacity and reduce travel time (with 4 minutes for freight trains; Wendel, 2007a). Three phases have been distinguished (Van den Berg, 2008):

- phase 1: free junction at Oberhausen-West. This is ready;
- phase 2: reduction of block length (shorter follow-up times) between Emmerich and Oberhausen. DB Netz tried to follow a so-called short procedure, which was not allowed. Now a complete plan study procedure has to be followed, which means a delay until 2011;
- phase 3: 3rd track Zevenaar-Emmerich-Oberhausen: planned for 2013. There will be approx. 70 additional train paths per day in 2020;
- additional phase: ERTMS conversion and change of power system - planned for 2012.

In Germany a major problem is the use of the Oberhausen-Wesel section by many passenger trains. This makes it necessary to extend the third track from Wesel towards Oberhausen. The additional capacity due to the third track will be consumed by growing traffic, however. This is why according to RDE/KV (2008) European harmonisation will not bring a lasting capacity improvement. Hence, the third track will be a short-lived solution.

RDE has looked into alternative options for the Emmerich border crossing. The Bad Bentheim border crossing also suffers from a growing number of passenger trains. Another option would be to divert traffic via Venlo. In this case there is the problem that locomotives have to be changed. The Dutch regulatory bodiy (Ministry of VROM) sees this (wrongly) as a marshalling activity, while its aim is to remove marshalling from Venlo because of the noise.

However, Venlo is well connected with the German network and RDE plans more trains via Venlo if the Brabant route and the Emmerich section reach their capacity limits (RDE/KV, 2008).

A Dutch-German plan study for Zevenaar-Emmerich section is underway. A technical committee will make a detailed technical requirements analysis.

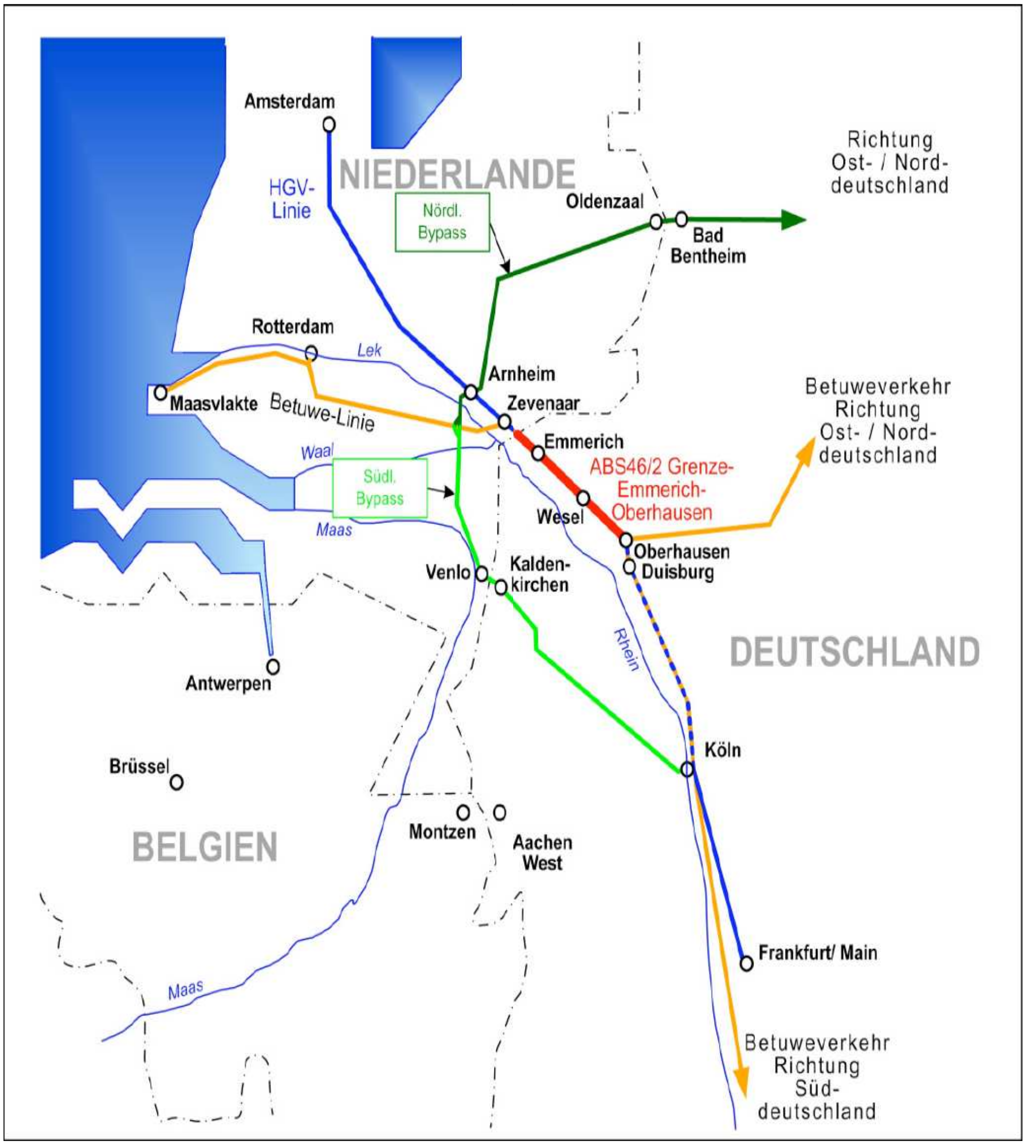


Figure 7. The German Betuweroute connection project

Source: DB Projektbau, 2008.

9.4 Specific ERTMS implementation issues

Earlier in this chapter we discussed many issues in a more generic way. Here specific issues, some of which are still not solved, will be elaborated. To be mentioned are (Ministerie van Verkeer en Waterstaat, 2006):

- safety issues;
- development issues.

9.4.1 Safety issues

Important safety consequences exist when freight trains use tunnels, when maintenance staff works in between the tracks and in case of accidents. This is a quite complex field, especially because safety is not governed by one (public) agency, but (illogically) divided over various, relatively autonomous organizations. As some technologies were quite new for them, a lot of preparation, testing and training was needed. This explains why it took a lot of time before solutions acceptable to all parties could be found. This led to an extension of building period of the Betuweroute.

9.4.1.1 Tunnel safety

In the tunnels TTI (Tunnel Technical Installations) have been installed. TTI include hard- and software for ventilation, drainage and water barriers, visual inspection (cameras), train detection, fire detection, telecommunications, fire protection (sprinklers) and (emergency) light. Many of them work fully automatic, which may have important consequences for railway operations. There have been many problems when installing these systems and they are still not fault-free (Ministerie van Verkeer en Waterstaat, 2008).

9.4.1.2 Maintenance

Railway maintenance means access to railways by authorized staff and maintenance equipment (more details in chapter 5). The Betuweroute differs substantially from other Dutch railway lines. Especially the installation of 25 kV AC asks for higher safety requirements compared to a 1500 V DC installation. In the latter situation relatively a relatively simple mechanical short circuit ‘lock’ would be employed, which would not only remove the risk of electrical shocks during maintenance, but also set the lineside signals to red, preventing any train to enter the secured zone(s).

With ERTMS and 25 kV the situation is different. This is why a decision was made to give maintenance people the option of local control of ‘work zones’. Before maintenance starts, a ‘work zone’ is defined, marked by entry and exit markers, and mechanically and electronically disconnected (switches are set to divert traffic and ERTMS is used to control the braking curve of incoming trains). Next, traffic process guidance is transferred to a special field officer. He becomes ‘owner’ of the working zone via a remote control unit called Handheld Terminal (HHT). Via a HHT he can communicate via GSM-R with the BEV21 ERTMS system. The HHT enables communication with the signaller, local control of installations (track sections, set or lock switches) and status information. Local control can be reverted to the central traffic controller (VL) or another field officer. More than one local lock can be installed in a working zone and all of them have to be removed (each by the original owner) before any trains can use the work zone. Local control is always supervised by BEV21. The HHT is only a command entry and status information terminal to communicate with BEV21. A local officer can never interfere with safety requirements in any way. This HHT, together with new procedures for working on infrastructure help to establish the necessary conditions for safe working on tracks (Wikipedia, 2008b).

9.4.1.3 Train incident management

Rail transport is one of the safest modes of transport. Nonetheless, incidents like derailment and fires can always occur. Incidents with freight trains, regularly carrying dangerous goods, such incidents can also have an environmental and health impact.

After an incident occurs, safety staff, like firefighters and police, need access to railway facilities, like tracks, installations, tunnels and buildings. Firefighters also need a lot of water to properly carry out their work.

Here the complexity starts. The A15 trajectory of the Betuweroute has the most modern - very high - noise fences in accordance with regulation for new railway lines. Parallel to the railway line there are also small drainage canals. The 25 kV power system carries a risk of touching high-voltage powelines and earth loops. The tunnels, fences, canals and high-voltage installations make it difficult or even dangerous to access the beforementioned facilities with external equipment like active fire extinguishers.

The drainage canals are also used to supply water to firefighters [17]. It turned out that the required capacity was not always available, especially in dry periods.

As a result, the local fire safety institutions first rejected these conditions. Later some solutions were found:

- local switch-off of the power system;
- increase the carrying capacity of drainage canals.

After a number of vital incidents, the interest for safety has increased substantially. In case of railways, special plans were developed, so-called Train Incident Management Plans (TIM). In

[17] The A15 trajectory is largely outside populated areas. As a consequence, the special pipeline system supplying water to firefighters is not available.

these plans, public bodies responsible for safety, together with railway officials, develop Train Incident Scenarios (TIS) for railway incidents. These scenarios are translated into procedures, which are contained in the Guidance for the Preparation of Train Incident Management ('Leidraad voorbereiding treinincidentbestrijding'). The TIMs receive final approval from majors, police and the regional ProRail management (Spoorwegincidentbestrijding, 2008).

The four major railway projects, including the Betuweroute, that have been or are being carried out in the Netherlands in the past decade have been assessed by an independent advisor (Ministerie van Verkeer en Waterstaat, 2006).

9.4.2 Development issues

9.4.2.1 Standardization

Standardization of railways is a complex process. On the one hand, defining and implementing standards helps to create an open platform for technology, generating economies of scale. On the other hand, standardization is also commercially complex, because companies have to develop their technology in a certain way and eventually accept solutions (modules) developed by others and even pay to incorporate them into their final products. From an industry like software development we know that standards frequently are issued by means of commercial dominance ('closed system') and less likely by co-operation among firms of equal size.

9.4.2.2 Train-track integration

An open system means that infrastructure built by company X should communicate with trains from company Y. This so-called train-track integration is complicated in the following ways:

- RUs may have <u>different operational requirements</u>. If a RU does not need shunting, its functional specification (set of tasks) can be reduced. In the opposite case, if a country needs additional features, like a special signalling regime, then the functional specification will be extended. These different functional specifications lead to different technical specifications, hence ERTMS implementations. Such local differences are also allowed by EU regulation. Implementation of ERTMS in trains passing through different countries should be able to overcome these differences, otherwise interoperability is at stake [18];

[18] An alternative would be to define a wider spec and then make some functionality inactive.

- the technical specifications of ERTMS are being developed in a complex process, in which a mix of technical, economic and political motivations determine standardization. Since local requirements may differ and some countries have additional requirements (like backward compatibility between SRS versions), standards are sub-optimal compromises;
- suppliers of railway infrastructure hard- and software do not start from scratch. They have invested in certain successful technology families, which means de facto standardization at the firm level for conventional signalling technology. Their decisions are therefore by path-dependent, which means that leaving such families in favour of externally induced standardization has to pay-off in terms of larger sales, otherwise firms will continue to develop technology in a non-standardized way as they need it. Business interests and patents may limit the level of standardization and co-operation between suppliers;
- “ERTMS specifications allow for different interpretations by the Railways and the suppliers, which results in solutions which are not fully compatible. Extensive testing is required.” (RINA et al., 2007, p. 55). Following Alstom (2004): “standardisation needs joint efforts from all parties to translate such work into tangible results”.

There are several suppliers of ERTMS equipment, both for hardware and software, some of them are also suppliers of other railway infrastructure modules or rolling stock. Each of them has made his own products, which even if they are standardized at a functional level, will likely not be fully standardized at the technical level. This means that a train equipped with ERTMS from supplier A is likely to work well with infrastructure developed by supplier A. However, there is a real chance that trains equipped with ERTMS from supplier B will not run without problems on infrastructure equipped with ERTMS from supplier A.

It is exactly this what we see with ERTMS as implemented on the Betuweroute. Alstom ERTMS Level 2 equipment was built into the tracks. Trains equipped with ERTMS OBUs from Alstom can use the Betuweroute without problems. This means that train-track integration was successful in this case.

However, OBUs supplied by Bombardier do not integrate yet with the track infrastructure. Certification at ERTMS Level 2 is not finished. This means that locomotives equipped with Bombardier OBUs cannot be used at Level 2.

For Level 1 locomotives have to be tested separately and get an additional acceptance license. In case of Alstom this license is relatively easy to get, but in case of Bombardier this will be more difficult. In general, licensing and testing of train-track integration (at SIL4 level) is a long lasting process (Pierick, 2008).

9.5 Summary

Lack of interoperability reduces the competitiveness of rail transport with road transport. Improvements in this area are important for the future of rail transport. Two issues are of particular relevance here: interoperability of signalling and power supply systems.

In Europe, ERTMS and a 25 kV power supply system are regarded as future, interoperable systems. Both have been installed on the Betuweroute.

A uniform power supply system allows cross-border through trains, replacing locomotive changes at the (system or national) border(s) or multi-system locomotives. 25 kV highly increases available traction power compared to the existing Dutch 1500 V, allowing a smaller number of locomotives to pull much heavier (and longer) trains, with important operational benefits. Co-existence of 1500 V DC and 25 kV AC is now regarded as possible in the Netherlands, however, there is an operational penalty if trains leave a 25 kV track section and move into a 1500 V track section.

A uniform signalling system, ERTMS, replaces a large number of national/regional signalling systems. In a few decades, if both rolling stock and most of the tracks have been fitted with ERTMS, train operation should become much simpler, as locomotives can be used freely in Europe, instead of the current limited national/regional deployment. In a future ETCS Level 3 situation, a more efficient use of capacity is aimed at, but Level 3 is only available at the drawing boards of its suppliers.

The marketing by its supporters and support by the EU should not induce us to forget that in practice a migration to ERTMS is a very complex venture. It is also a very expensive system to install. On the other hand, vital replacement parts for existing signalling systems will not be available much longer, which means that they would have been replaced anyhow. Gradual replacement of existing systems eases the financial burden to some extent, while in some cases less advanced versions of ERTMS could be introduced. ERTMS allows software-based upgrading, instead of hardware-based like in present systems. If this is better, remains to be seen.

On the Betuweroute, it has become apparent that ERTMS will introduce operational limitations. ERTMS was developed keeping for high-speed passenger trains, and not for freight trains, which have much different operating characteristics. Braking characteristics and procedures for (heavy) freight trains are (completely) different than those for passenger trains. Complex train movements, like shunting, are also difficult to address with ERTMS.

Integration of all technical systems has been a very complex technical challenge, especially in tunnels. At present, ERTMS is not functioning all the time as expected.

Developing ERTMS as a system has been a real challenge. An assessment gave the following key answers to the question of what went wrong during the development of ERTMS (on the Betuweroute):

- parallel phases of development and execution causing rework and delays;
- immature ERTMS producers, not capable to find general solutions for local issues;
- no effective system integration because of lack of a clear system integrator.

Both the Dutch government and the contractors have made many mistakes. However, now trains are running, one could say that such a new project, and especially the introduction of ERTMS, finally helped to make the whole development process transparent. All aspects have been formalized in documents and rulings, leaving no subject untouched. Hopefully, new projects will benefit a bit from these analyses.

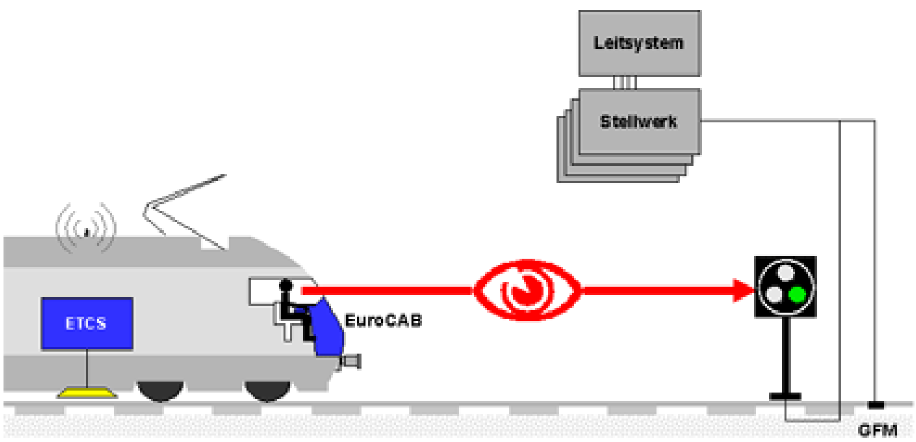
The Betuweroute is a small section of the Rotterdam-Genoa corridor. Installation of ERTMS and 25 kV on the Betuweroute should also be carried out in the other countries along this corridor. To some extent, this is already happening. If completely installed, and a common corridor management is also installed, then RUs can really benefit from these new systems.

Appendix: ERTMS levels

This section elaborates the basic set of ERTMS/ETCS levels.

ERTMS/ETCS Level 0 (Unfitted)

In this case a train equipped with ERTMS uses a trajectory not equipped with ERTMS. ETCS monitors and manages the maximum speed and the driver follows guidance from conventional signals. There is train detection, but no contact with the RBC (external train management), hence this is an inherently unsafe mode. The train driver reduces locomotive speed to 40 km/hour and then switches from one system to the other.

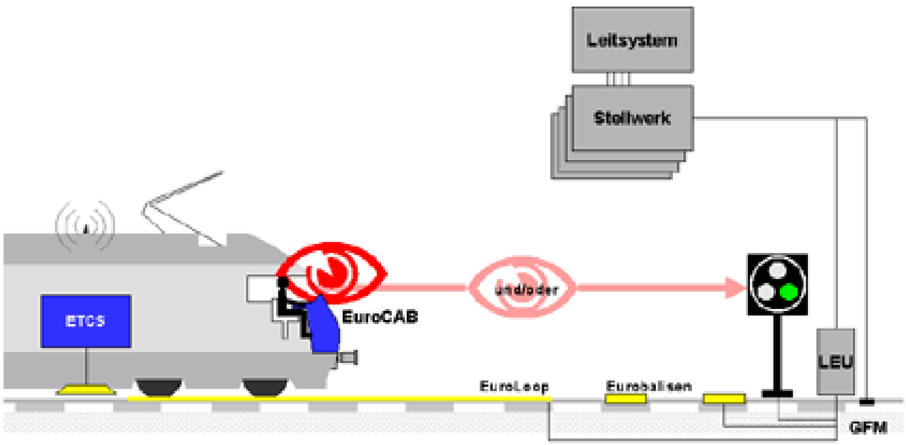


ERTMS/ETCS Level STM

Level STM (Specific Transmission Module) is used if a train equipped with ETCS uses a trajectory equipped with a conventional national signalling system, which will not be replaced in future. This may be called an 'isle' in the safety system. A ETCS-STM onboard the train translates the information of the national system into messages readable by the ETCS onboard system, which are then send to the DMI LCD of the driver. Safety is equal to that offered by the conventional system. Train detection and integrity management will be managed by means of electrical loops or axle counters (Viaene, 2005).

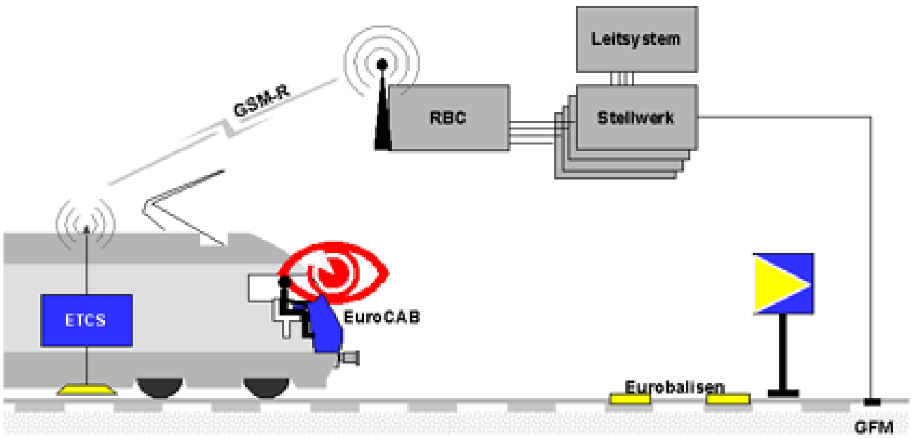
ERTMS/ETCS Level 1

Level 1 is an intermittent signalling system, which means that trains are monitored at specific points on the line. Signals give visual indications. Beacons (called Eurobalises) inside the track are used for move authority. Beacons communicate with a receiver in the locomotive telling the driver what to do. Continuous communication is possible by means of a Euroloop (a coaxial cable inside the tracks) or Euroradio (a radio connection). This is called Level 1 with ‘infill’. Traditional block systems remain in place and train detection is done by means of electric loops or axle counters. Existing lineside signals remain in place, although they are in fact redundant. Level 1 is comparable to ATB-NG; both rely on intermittent braking curve. Level 1 will be used as a fall-back option for Level 2 in case the GSM-R connection disappears temporary. Without this fall-back trains could only run 20 km/hour (‘driving on visual’).



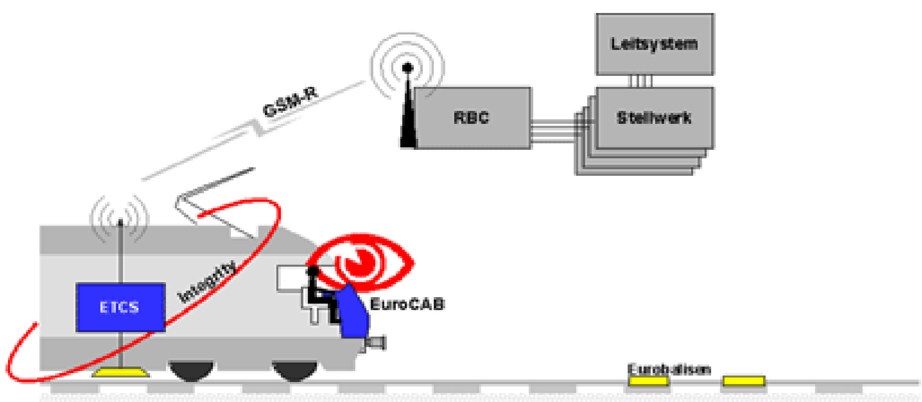
ERTMS/ETCS Level 2

In Level 2 train guidance is performed by so-called Radio Block Centres (RBCs). An RBC communicates continuously with a train by means of Euroradio (GSM-R). Eurobalises are used for precise location of a train only. Lineside signals are removed and replaced by cabin signalling devices. Train detection is done by means of electric loops or axle counters. SMBs (Stop Marker Board) with blue-yellow shields are used to tell the driver where the locomotive should stop in case of a ‘stop’ order. On his display the driver sees how he should reduce the speed in order to stop in front of the SMB.



ERTMS/ETCS Level 3

Level 3 resembles Level 2, however train detection and management of train integrity are taken care of by an RBC using information supplied by the train. GSM-R also monitors the safe rear end of the train. This allows the infrastructure provider to endorse the train driver with reliable movement authority. As a result of this, there are moving blocks. The length of moving blocks depends on the characteristics of subsequent trains. Train length and speed are leading parameters here. There is one yet unsolved issue: there is no train detection in the infrastructure. The driver enters the length of his train into the system, but if it would be split incidentally – loosing one or more wagons, the system will not be informed about this. In conventional block systems such a failure would be detected immediately.



Sources: Viane (2005), SBB (2007) and ERTMS (2007b), Stoop et al. (2008).

10. Corridor A: Rotterdam-Genoa implementation plan

10.1 Introduction

The Betuweroute is the start and finish of several main European rail corridors, both east-west and north-south oriented. In this section we will deal with the following:

"Development of an implementation/action plan for future freight service and operation on the Betuweroute as basis for demonstration under consideration of the results of the MoU between the European railway associations and the EC for corridor A (Rotterdam to Genoa)."

In other words, we will describe how the Betuweroute will be integrated in the backbone of European transport: Corridor A (Rotterdam to Genoa).

The idea of corridors is an important deviation from the past, in which national objectives dominated infrastructure development and management to a large extent. In the past the road transport market has been liberated, allowing trucks to move relatively freely across Europe. In order to compete more successfully with road, rail transport should enjoy the same position. Hence the need to reduce barriers to entrance of markets and to consider rail infrastructure networks from a European perspective.

10.2 Corridor A in brief

This rail corridor connects the North Sea with the Mediterrenean Sea over a distance of some 1500 kms. During a full trip along this corridor a train crosses the Netherlands, Germany, Switzerland and Italy, passing all sorts of terrain (see Figure 7).

Many bottlenecks along this corridor delay a swift movement of (freight) trains: a lack of interoperability (due to the many different technical systems and procedures), infrastructure bottlenecks (lack of capacity, steep and curved trajectories), delays due to change of locomotives and staff, and a lack of integrated management of services (full functioning one-stop-shop).

At the same time, international rail traffic along this corridor is expected to almost double in the period between 2005 and 2020 (from 28,5 bln. ton-kms to 56,6 bln. ton-kms), which indicates a modal shift of some 3.5%. The ongoing growth of road transport adds to the already existing congestion in road transport and its impact on the environment and liveability. The urgency to deal with these issues led to the signing of a Memorandum of Understanding (MoU) between the governments of the four countries involved. This is one the six MoU that are foreseen as part of the EU TEN-T program. Cross-border projects in this program are entitled to a 50% EU subsidy for tracks and trains and 20% for ERTMS installations.

After this MoU, a special organisation was established according to EU law, a so-called EEIG (European Economic Interest Group), able to do bussiness in many European countries.

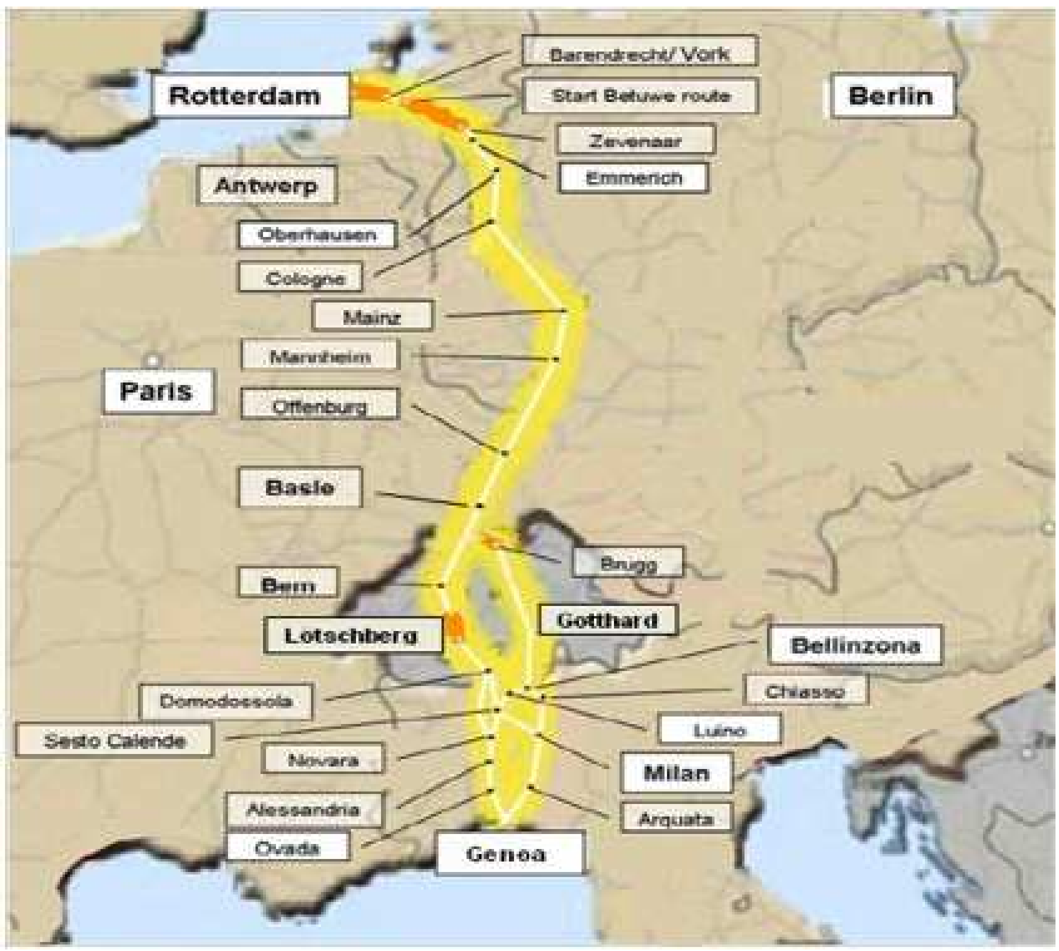


Figure 7. Corridor A with main nodes

Source: Wendel, 2007a.

10.3 Towards a business plan for Corridor A [19]

10.3.1 Introduction

In order to ensure that the forecasts concerning the growth of rail transport and the shift from road to rail in this corridor are sustainable, a business plan was developed. It covers the period 2007-2015. The plan gives a consistent and complete overview of all measures planned by the infrastructure managers in this corridor, the benefits resulting from these measures, necessary investments and challenges for funding, an implementation timeline and a programme organisation. So, the Business Plan does not deal with the question ‘shall we do it or leave it’, but with the question of ‘how to do it right’, where ‘it’ refers to improved railway performance.

10.3.2 Specific aims and benefits

The aim is to significantly increase the competitiveness of rail cargo by

- increasing reliability by 26% overall and 50% on the Betuweroute;
- increasing capacitty by 52%;
- reducing transport time by 20% (from 25 to 10 hours transit time);
- reducing cost per unit by 10-15%, plus improvements within the RUs.

These targets are regarded as necessary, because reliability and capacity are already under stress.

If the aims of the business plan are realized, rail cargo should be able to improve its market share by 3.5 percentage points by the year 2020, effectively doubling transported volume.

For the environment such an increase is regarded as beneficial, due to the lower environmental impact of rail versus road.

10.3.3 Tools to achieve the aims and benefits

A set of tools will be used to match these targets. To be mentioned are the following:

- realisation of interoperability;
- elimination of infrastructure bottlenecks;
- realisation of a total service concept (Section 10.4).

The importance of interoperability has been discussed in section 4.2 and Chapter 9.

Elimination of infrastructure bottlenecks in this corridor is done by a series of infrastructure

[19] Main source: Wendel, 2007a.

projects. These can be distinguished into projects

- already started and near completion;
- planned for the near future;
- needed, but not definitely planned, yet.

Investments in Corridor A will amount to some Euro 34.9 bln. Euro 10.6 bln. of this amount has already been invested before 2006, the remaining Euro 25 bln. should be spent until the year 2021. One should realise that for only Euro 12 bln. of these Euro 25 bln. funding is found. The high investment level explains why some countries try to find less expensive solutions for infrastructure expansion or upgrading.

Most of these investments are for new or improved rail sections, while a small part is for the introduction of ERTMS (Euro 0.8 bln.).

10.3.4 Implementation timetable

There is no synchronised investment plan for the whole corridor. Each country invests according to its own timetable. This has important consequences. If some sections are upgraded in order to increase capacity and this capacity is consumed by a higher demand for rail services, then other sections, which will not or at a later moment be upgraded, have to cope with additional traffic (Wendel, 2007a). Several important infrastructure projects will be finished in the period 2015-2021, especially in Germany, Switzerland and Italy.

ERTMS planning is synchronised, however. It should be available in the whole corridor by 2015 (some parts already in 2012).

The following factors are regarded as success factors for the corridor:

- co-ordinate implementation;
- priority to quick wins (low cost – high benefit);
- consistent time scheduling (reduce time to market, coherent ERTMS implementation);
- commitment to full corridor programme;
- integrated responsibilities, managed by EEIG;
- strong co-ordination and co-operation with RUs.

10.4 Co-ordination and Total Service Concept

10.4.1 Introduction

Interoperability is partially a technical issue, but at least as important is the issue of interoperable information systems, supporting planning and management of freight railways.

For the Betuweroute, the issue of corridor management was described in several sections of Chapter 3 and 4. In this section, we will broaden the geographical scope and look at the whole corridor.

10.4.2 Traffic management

This consists of three basic processes:

- capacity management;
- traffic control;
- performance monitoring.

In an ideal world, these three processes are integrated in an IT-system. There have been various attempts to develop modern IT tools to support these functions in all of the countries concerned. Sofar integration is incomplete, even at the national level.

The idea of the business plan is to develop a Total Service Concept based on the EU TAF/TSI (telematic applications for freight services) standards of 2005. Following these standards, common structured common processes and harmonized information should be available for all parties in rail freight services.TAF/TSI is directly related with the Strategic European Deployment Plan (SDEP) as developed by the UIC IT Study Group.

Information about path requests and availability, train composition, trains running, transport order information and wagons status information should be available to all interested parties. In this way transparency, reliability and efficiency of rail freight transport should be increased (substantially) (Wendel, 2007a).

10.4.3 Total Service Concept (TSC)

A TSC aims to improve corridor services by (Wendel, 2007b, p. 31)

- “Joint operations management
    - optimised corridor control centres
    - real-time train information sharing
    - one-interface corridor managers
- Integrated path management & marketing
    - One-stop-shop for paths
    - Pricing transparency
    - Integrated planning of train paths
    - Harmonized priority rules
- Integrated consignment note management
- Joint wagon reference data management

- Harmonised driver's licensing
- Efficient border operation rules
- Real-time wagon movement transparency
- Dynamic trip planner
- Flexibility of freight trains in facilities
- Harmonisation of operational rules."

10.5 Summary

The Betuweroute is the beginning (or end) of Corridor A (Rotterdam-Genoa). A succesful integration of the Betuweroute in this corridor consists of a set of activities:

- technical integration (see also chapter 9);
- new and upgraded infrastructure: next to the Betuweroute also major upgrading of infrastructure in countries like Switzerland and Germany;
- economic co-operation.

Economic co-operation and integration is supported by a joint Business Plan for the corridor. The aim of this business plan is to increase reliability and capacity by 26 and 52% respectively, while reducing transport time by 20 and 10-15% respectively.

Infrastructure managers, governments and RUs should co-operate closely in order to reap the full benefits of this business plan.

The issue of co-operation is key to the Total Service Concept as developed in the business plan. It is particularly relevant for trains crossing borders. International customers having the choice between road transport with its relatively simple interface to the customer and rail, frequently get lost with the latter. They do not want to deal with a great many of actors and non-familiar issues, as is common when one organizes a train service, let alone in case of problems with a service. Reduction of complexity for customers is a key issue for RUs and infrastructure managers alike. A one-stop-shopping concept, as the solution is called, demands a common IT-application, in which capacity management, traffic control and performance monitoring are integrated. This assumes that a great many of the present operational and tactical bottlenecks in the railinfrastructure have been removed.

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- Mr. Jérôme Schmidt, Unitmanager Operations, July 31, 2008.
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