De Nederlandse Mededingingsautoriteit

Market Assessment for ProRail ICT-Systems in Traffic Control

Den Haag/Hamburg, June 2008

BSL Management Consultants GmbH & Co. KG

Executive summary

This analysis on behalf of NMa provides an assessment of the market for ICT-systems for traffic control with regard to ProRail. It has looked at relevant markets from an international perspective, their functioning and competitiveness and trends for future developments.

A view is also taken at ProRail's procurement approach for supply and maintenance of hard- and software in this context. Risks and opportunities thereof for the quality of ProRail's performance are related to international experience.

The assessment is based on a broad range of collected evidence, both in The Netherlands and internationally. Particular emphasis is on current practices in other railway systems and a direct view on the market from the perspective of key-suppliers and service-providers themselves.

At the submarket of hardware equipment, railways can participate on a highly efficient, global competition for standard components, if appropriate conditions are set in tendering.

The market for software applications however is not a classical, mature market in the sense of relatively standardized applications ("products"). Individual case-by-case solutions still dominate the scenery in Europe, while trends towards more standardisation are in their infancy.

Hence, the origin and market-presence of key-suppliers is international. The leading-edge of them pushes the use of cost-efficient, industrial standard platforms, also from other sectors like aviation, for customisation on the individual requirements and varying operational needs of railways. This gives also the software market to a growing extent not only a European, but a global dimension. On the other hand, the European efforts to impose some standards "from above" are widely seen as a longer-term issue that will not immediately change demand patterns and market behaviour.

Today's role of ProRail at these markets is the one of a buyer, who is still faced with legacy ICT-systems for traffic-control which were developed in-house more than two decades ago. These systems are perceived by many industry-observers to be at the end of their lifespan. Although they are not the single-most important cause of traffic perturbations in the Dutch railway system, they nevertheless have a strong and highly visible impact for the general public due to the sometimes disruptive nature of incidents on operations.

In a recovery effort from a significant spin-off of system knowledge in the context of the Dutch railway reform in the nineties, ProRail has taken important steps to bring the systems back into better control. These were namely the reassembly of

an in-house knowledge-base to define system requirements for railway operations and the stepwise redevelopment of key-modules in order to bring ICT-systems back to a state of well defined and documented quality.

ProRail already procures the development of system modules on an open, competitive basis from the international market and subsequently integrates it into its present architecture. It should go further into this direction and prevent itself from a reaction of "falling-back" to overly excessive in-house strategies.

ProRail can grasp opportunities from market-developments and technology-trends and push them actively for its own benefit. Experiences from other European railways, which developed their core ICT-systems for traffic-control in decisive and ambitious ways, should encourage ProRail to explicitly consider further system enhancements, that clearly promise a path to better system reliability as by cost-efficient use of industrial standards, more upward compatibility with ongoing technical innovations but also, and very importantly for The Netherlands, the exploitation of some capacity reserves for the existing network infrastructure.

Content

1. Background and Objectives

ProRail is a state-owned company supervised by the Ministry of Transport ("Ministerie van Verkeer en Waterstaat"), which holds the business concession of the Government of The Netherlands to manage the Dutch railway network. As part of the governments' oversight, a working group of the "vaste commissie voor Verkeer en Waterstaat" presented a set of suggestions, the so-called report "Op de Rails", in 2005 to improve the performance of ProRail. Two years later ProRail provided a report on proceedings related to these suggestions, the so-called "Op de Rails progress report".

In addition, the High Commission asked the Ministry to initiate an examination about the efficiency and effectiveness of ProRail as a reaction to perturbations in traffic control systems – Utrecht and Rotterdam in February 2007 and Amsterdam in March 2007. Two activities were thereupon launched:

- a second opinion about the "Op de Rails progress report", which was provided in the meantime by McKinsey & Company,
- an assessment of (supplier) markets for the development and maintenance of Information and Communication Technology (ICT) in traffic control by BSL on behalf of The Netherlands' Competition Authority (Nederlandse Mededingings-autoriteit, "NMa").

Findings of this assessment are summarised in the following report. Interfaces between the two activities were discussed mutually between McKinsey and BSL.

Based on the NMa-specification, the **objectives** for the traffic control ICT-market assessment are

- to determine the **competitiveness** of the respective (sub-)markets for system development and maintenance,
- to provide a judgement about **risks** for quality, price and system compatibility in the case that the market was not considered being sufficiently competitive.

Among others the following **questions** were considered as guidelines for the assessment:

- Which are the relevant markets (both in terms of products and geography) that serve ProRail to obtain their products and services for ICT systems in traffic control? (chapter 4)
- How important is the differentiation between hardware for installation and operation of ICT-systems on the one hand and software for the system development and maintenance on the other? (chapter 5)

- Who – explicitly – are the suppliers and customers? To what extent do they act domestically or internationally? (chapter 5)
- Which significant developments and trends can be identified and what is their potential impact on the effectiveness of the market, e.g. possible entries and exits of market players? (chapter 6)
- What are entry barriers for the various sub-markets, e.g. intellectual property rights or governmental regulations? (chapter 6)
- How compatible are components and services provided by different suppliers? How important is compatibility for the effectiveness of the market? Which risks can be identified and how can they be mitigated? (chapter 6)
- How do current procurement and contracting practices impact prices and the speed of delivery? What can be done to improve market-effectiveness? What can be learned by other infrastructure managers internationally in this respect? (chapter 7)

The assessment builds on an analysis of the systems and suppliers as well as the current procurement by ProRail on the one hand and on the evaluation of selected international "good-practice" examples on the other.

2. Method of Approach

Based on a combined approach of the domestic situation in The Netherlands and international good-practice analysis, the study is built on three modules.

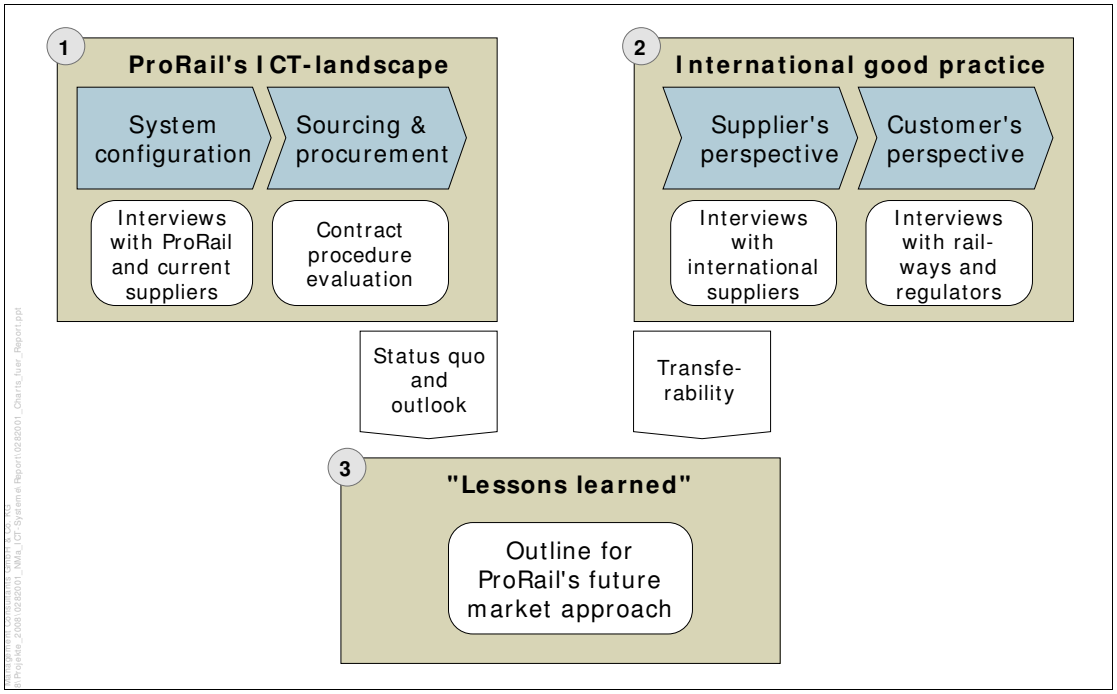

Figure 1: General approach in three separate modules

Module 1 provides in a first part an overview of ProRail's ICT-core applications in traffic control with some attention to their development background and future challenges. The second part of this module is a description of the ICT-related "sourcing behaviour" of ProRail and an assessment of its appropriateness to meet future challenges and to obtain products and services in line with international performance standards.

Information was gathered from interviews with technical and procurement experts from ProRail's ICT-department, the central procurement unit ("AKI"), the recently created unit for system maintenance ("Beheer non stop", BNS), NS Reizigers as the largest operator on the network and the legacy-system maintainer TriBase and the IT-company Logica as selected business partners of ProRail.

In the parallel module 2, international practice was studied in a selected sample of European countries. Interviews were conducted with several experts of Swiss Federal Railways (SBB), German Federal Railways (DB AG), the Spanish infra-structure manager ADIF, the Swedish infrastructure manager Banverket and to complement the picture with the European Commission (DG TREN) as driving force for standardisation issues.

Supplementary to the discussions with railways, an exchange with application and software providers, expert developers and system integrators was conducted about their respective views. Interviews on this behalf covered representatives of (in alphabetical order) Accenture, CSC, Funkwerk, Indra, Steria and Thales.

This module led to an overview of market trends, an external view of ProRail's ICT-situation and an international appraisal of market development strategies.

Module 3 then draws conclusions about relevant markets, their characteristics and trends and the resulting implications for ProRail.

Market analysis refers specifically to software applications and hardware of the systems. For both sub-markets supply and development on the one hand and maintenance services on the other are considered.

Attention is given to characteristics of these markets, like the set of relevant buyers (being mainly state owned rail infrastructure companies), the set of suppliers in each market, degrees of product standardisation and specifics of the market for maintenance services.

Thereby module 3 is ultimately leading to implications and suggestions for the future approach of ProRail to deal with the relevant ICT-markets.

3. Scope of Analysis

The study concentrates on the supply and the maintenance of ICT-components which are directly relevant for quality of traffic operations, albeit with some consideration to interfaces with neighbouring systems (see figure 2).

The related components are mainly traffic control functions, which are covered at ProRail by the system family called "Vervoer per Trein" (VPT). Core functionalities comprise the operations management ("Verkeersleiding") and the corresponding management of route setting infrastructure ("Procesleiding").

The market analysis therefore has a focussed scope compared to the wider examination of processes at ProRail which was simultaneously carried-out by Mc Kinsey on behalf of the Ministry of Transport.

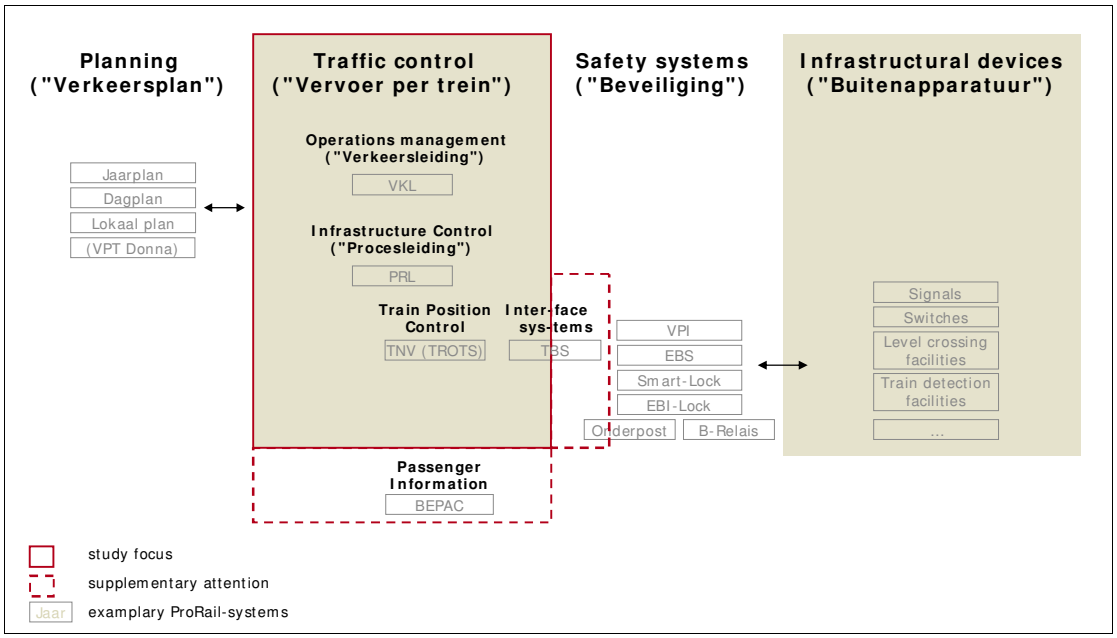

Figure 2: Focussed Systems and Applications

It is important to note that, both with respect to overall expenditures and to performance, ICT for traffic control represents a small part of the wider train control and signalling system.

Out of the major investment that is earmarked for the refurbishment of the aged relay-based train-control installations in The Netherlands and for the migration to European standards in signalling (ETCS), traffic control ICT represents an order of magnitude of 10% only.

Experience from peer railways on a European scale shows that effects of traffic-control on operational perturbations are at low single-scale, sometimes even hardly observable ranges. Thereby system enhancements are rather driven by the aim to enhance network capacity than being immediate reactions to perturbation problems.

In The Netherlands, the "un-planned" non-availability of railway infrastructure (regardless previously scheduled track interruptions) was 0,2% in 2007. Traffic control ICT accounted for about 27% (January-April 2008: 9%) of non-availability times, which is broadly equivalent to some 3-7% of all train delays based on international experience.

Although traffic control ICT is thereby "only" the second most important cause of infrastructure failures for ProRail and data are indicative only since statistics are sparse, its impact is high in European terms and strongly visible for the general public and political actors due to the sometimes disruptive nature of incidents on operations.

4. ProRail's traffic control systems and supplier markets

4.1 Genesis of systems and suppliers

In order to understand ProRail's current traffic control system landscape ("VPT") and the position of incumbent suppliers some attention to its genesis is useful.

The VPT-landscape was originally an in-house development of "Nederlandse Spoorwegen" (NS), initiated in the mid-eighties and rolled-out between 1994 and 2000. The system architecture reflects the then integrated structure of NS. Besides key-functions of train path allocation and train control, several subsystems cover immediate control of infrastructural devices and also operator-related issues as the planning of train-crew rosters.

In order to connect VPT with the existing, strongly diversified systems on the safety level, various kinds of regionally specific interfaces became necessary. This led – among other reasons - to a high degree complexity of configurations and heterogeneity of data-models, which turned out to be a notorious problem for the robustness of the system.

In the context of railway restructuring in The Netherlands, which took place in parallel with the roll-out of VPT in the mid-nineties, previously internal functions of NS were spun-off into the market. This refers also to the sector of traffic control. Considerable shares of experts, who participated in the VPT-development, were taken over by private companies, among them

- the NS "Centrum voor Informatieverwerking" (CVI), which was acquired by EDS, a global US-company with more than 9.000 IT-professionals world-wide within the transportation sector alone. EDS was granted a 10-year sales guarantee in this context, which was partly fulfilled by contracts from ProRail with regard to VPT,
- the former in-house "NS Ingenieursbureau", which was spun-off as "Holland Rail Consult" (now "Movares" with joint venture "Intraffic") and
- NS subsidiary Articon, which was sold to Arcadis.

Subsequently, ProRail had to rely on these suppliers for the development of new applications and VPT-releases whilst in-house competence on the subject was depleted. This had significantly shaped the Dutch market and is important to understand the current situation.

The maintenance of VPT was embedded (1997) into contracts with Volker Rail, Structon and BAM, that covered the servicing of the entire rail infrastructure within defined regions. Since regional ICT maintenance-units turned out to be

(too) small in terms of economics and knowledge and since interfaces between regional responsibilities were difficult to handle, activities were bundled into an "umbrella organisation" in 1998/99, of which Volker Rail, Structon and BAM were the shareholders. The TriBase-consortium emerged out of this organisation one year later.

Since then TriBase was the single-source supplier of ProRail for ICT system maintenance on the basis of annual contracts. In 2004, a 5-year lump sum contract was agreed upon. Under this contract a defined maintenance quality-standard based on agreed "performance indicators" was to be assured.

However, systems deteriorated to a state of perturbations that heavily affected train operations on the network. ProRail's statistics of system failures indicate that more than once a week a new type of problem is detected that – even if mostly not fatal - requires root-cause analysis, redesign and eventually the roll-out of a system release to solve it. This indicates that there are systems within the Dutch VPT-landscape which in their current state do no longer meet good-practice standards in Europe. The architecture and key-modules are seen to be at the end of their life-cycle by several market observers.

However, besides the functioning of software the spectrum of underlying causes for perturbations deals with a wider range of

- maintenance and upgrade works on ICT, which are affected by incomplete documentation and a limited testing environment to predict system behaviour,
- hardware-related issues, as a damaged hard disk being the starting point for the Amsterdam breakdown in March 2007 and
- energy and communication networks, which are in an ongoing process of advancement e.g. by replacement of copper by fibre optic cables.

An evaluation of reports about the most relevant perturbations in the period from 2005 until mid 2007 shows a variety of systems, which initially caused the incidents (see figure 3).

Incident	Malfunctioning system	Connected with		
		Works	Hardware	Networks
26th April 2005: Post Pijnacker	Signalling System EBP	x		
19th June 2005: Post Amsterdam	Train number detection system			
30th September 2005: Post Utrecht	Various			energy
20th October 2006: Post Utrecht	Interlocking System VPI			
22th February 2007: Post Utrecht	Plan Beheer Systeem PBS			communi-cation
1st March 2007: Post Amsterdam	Various	x	x	

Figure 3: ProRail-systems causing major incidents 2005-mid 2007

This underlines that system stability is not a matter of replacement of single "trouble-causers" only but needs an integrative approach on various components.

4.2 New strategy for procurement and market interaction

Some years ago ProRail started to address critical issues of its market situation and to deal with the challenges.

It was acknowledged that further development and stabilisation of systems requires leadership that can not be transferred to suppliers. Thereby ProRail embarked on a strategy in 2004 to re-assemble and strengthen its in-house competence. This applies to both the development and maintenance of traffic-control systems and the supply and operation of related hardware:

- an in-house ICT-department was installed in 2005 with (currently) about 140 internal experts, which were mostly re-integrated from former suppliers, and some additional 140 external employees from the market,
- resources from Arcadis and Movares are currently being attached closer to ProRail. As a first step, it was agreed with both companies to allocate expert know-how in a new company (Loxia), with which ProRail has formed a strategic alliance. For the medium term, a re-integration of resources into ProRail is considered as an option,
- in the sector of maintenance, the contract with TriBase was cancelled and resources are currently in a process of reintegration into ProRail. A new ProRail unit ("Beheer-non-stop", BNS) was created for that purpose, which is now responsible for all maintenance activities of traffic-control systems.

In doing so ProRail put itself in a position to re-gain system leadership and initiated fundamental reorientation of its procurement strategy.

ICT-products and services which are currently bought on the market under competitive European tendering from international bidders are

- Hardware installations (as server, PC's and related equipment)
- Software programming (as the re-development of applications)
- Maintenance services for hardware (as planned for the operation of the Double National Computer Centre DNCC, which implementation will start in 2008)

Tendering of system maintenance follows the supply sector with some time lag. Once renewed and well-documented system versions will be in use, supply of services from the markets is feasible. Hence, the time-critical first line-support will remain in the hands of ProRail while the use of market resources is envisaged for the later stages of system support. However, the definition of functional/technical requirements and the general system design as well as testing, system integration and the roll-out of new applications are currently decisively held within the responsibility of ProRail (see figure 4). This may be seen as a reaction to previous experiences with the outsourcing of the total system responsibility.

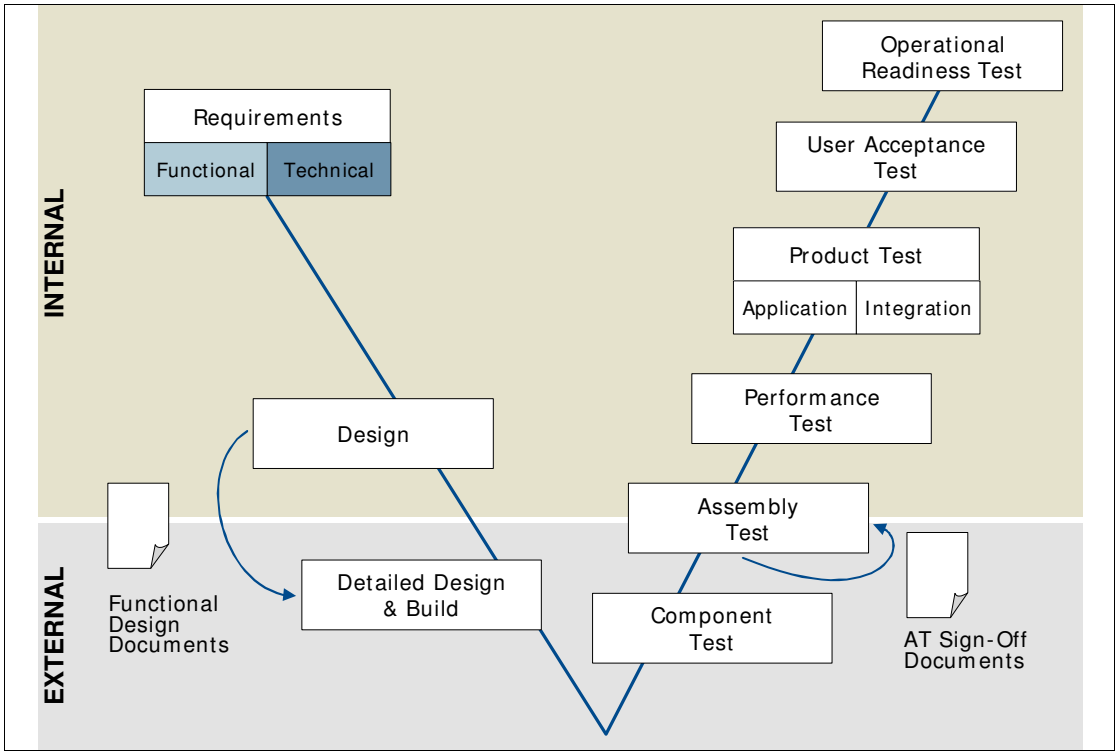

Figure 4 Principle share of responsibilities in ProRail's market approach for software development

As a result of this work-split approach, recent tendering for the development of software applications typically covered 15-20% of total project costs only.

However ProRail also draws on experts from the market to support in-house work stages. Half of the staff (and two thirds of the relevant budget) of ProRail's ICT-department consists of external experts (see figure 5 for origins by company). Hence, if accounting efforts for these "hired" experts as external project costs, the overall share of external services increases to 70% of total project costs, which is anyhow low compared to international experience in this sector (see chapter 6.1).

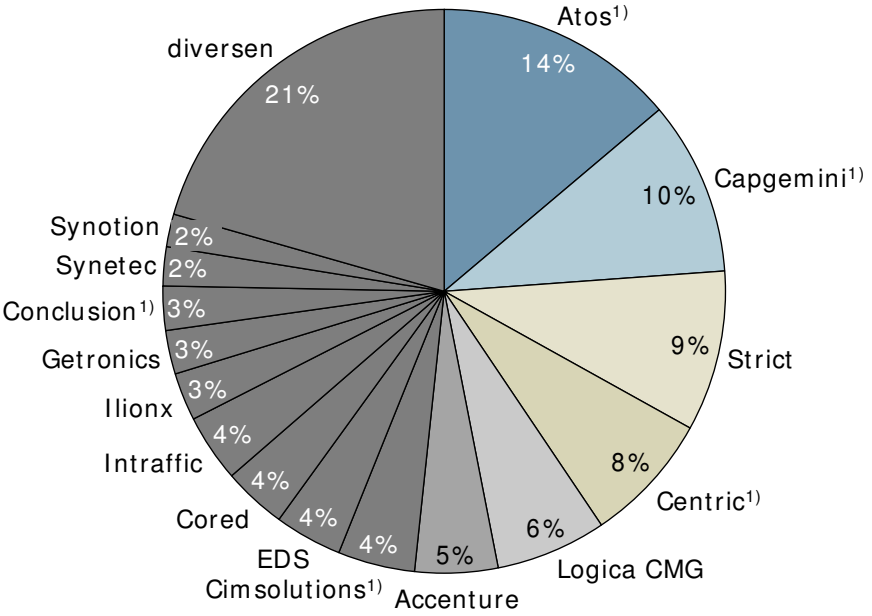

Figure 5 Expenditures for external experts within ProRail's ICT-department by companies (2007)

4.3 Current use of markets by ProRail

As a first step of ProRail's new procurement strategy the highly integrated architecture of the VPT system is currently being transformed ("with much time and effort") into a "service-oriented" structure that enables the development of individual applications by different suppliers, which are each connected to the main system by a "service-bus" technology.

More ambitious programmes are now planned and executed like the implementation of a centralised national computer centre with a fall-back level (i.e. a duplication of computing infrastructure), the conversion of communication networks into fibre optics technology, a comprehensive programme to redesign

the process of slot-allocation and operational guidance ("Herman") and a programme for the rebuilding of train control systems for route setting processes ("Astris"). In 2008 investments for IT will rise from 48 million € (2007) to 90 million €.

Under this programme, the work-stages from technical system design to programming and component tests of software-applications are planned and carried-out by suppliers which were chosen by public tender procedures.

The relevant market for **software (application) development** consists of companies which may be generally based internationally. However, it turned out that presence in The Netherlands is of great advantage, since close contact to the customer and Dutch speaking staff is required.

Thereby suppliers who recently participated in previous tenders of ProRail were – beside of ICT Automatisering as local bidder – international companies with branches in the Netherlands: **Atos Origin**, **CAP Gemini**, **EDS**, **IBM**, **ICT Automatisering** and **Logica** (in alphabetical order).

Company	Base	Characterisation	Remark
Atos Origin	France	global software company (50.000 exployees), created in 2000 by fusion of French "Atos" and Dutch "Origin"	ProRail's contract partner for the first test of a "software development fabric"
CAP Gemini EDS	France USA	see figure 7	
ICT Automatisering	Netherland	Large national developer for Industrial Computer Applications (1.000 employees, experience in traffic&automotive	long-standing partner of the Dutch transport sector (process/traffic management, information and ticketing systems)
Logica (former LogicaCMG)	UK	IT-company serving European markets with specific rail competence	won a ProRail tender for the development of a train number observation system in 2002

Figure 6 Participating suppliers in ProRail tenders

The range of bidders clearly reflects the scope of the tenders, which is software development without major rail background requirements. Accordingly, market participants rather emanate from the software branch than from the rail business.

The **relevant market for hardware-equipment** has to be considered in another way.

The most recent major ProRail-tender of this kind has been procured on a negotiated basis to Hewlett Packard in 2007. However, this was declared to be exceptional because of special compatibility reasons and time-constraints for delivery.

In general, it is recognised that systems have to be ready for easy switches to each new generation of technology standards that come up on the market. Thereby ProRail is able to make use of the global market for standard equipment, which covers effectively all suppliers of business computing (see chapter 5 for names).

5. International Market Overview

5.1 Demand-side

The demand-side of the European market for traffic control systems is formed by railway infrastructure managers respectively integrated railway companies.

A widespread perception prevails among them to have each unique conditions and requirements that do not allow for the use of "pre-fabricated" products. ICT-markets are rather expected to supply individual solutions than to be classical, mature markets in the sense of relatively standardised applications. Thereby the demand-side of the market is still relatively "domestic" in its nature.

Estimations about the market volume for traffic control systems with according technical installations and data networks are in the order of magnitude of annually 400 mio. € on a European scale.

Currently urban rail systems account for a third of the market. However, the share of the heavy rail sector will grow over the next years, since saturation of main lines increases the demand for applications to exploit capacity-reserves.

The most important national markets are Germany, Italy and Spain, which each account for annual market volumes of about 65 mio. € according to a recent survey.

Furthermore rail-based systems in the United Kingdom and France generate annual volumes of some 25 mio. €. Eastern European countries focus on other products yet and hold only a minor share (see figure 7).

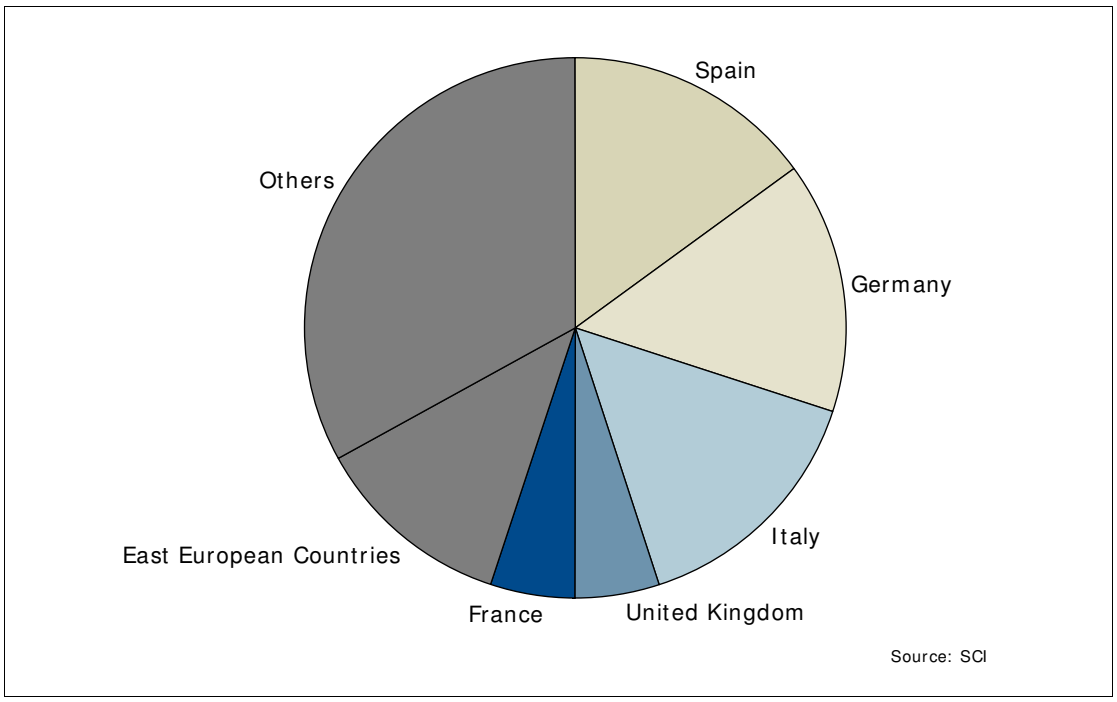

Figure 7 Overview of national market seizes for traffic control

New and upgraded systems represent the main share of demand, while maintenance and system rehabilitation account for annual investments of 30 mio. € only. This is an indication that complete system overhaul is an important issue for European rail companies (see examples in chapter 6 for the sample of railways examined in detail during this study).

5.2 Supply-side

The supply-side of the market is far more heterogeneous than the demand-side.

It is important to pay separate attention to markets for software applications and hardware components, since the grades of required explanation and customisation of products differ significantly (as the hardware market is much more standardised).

In the following, we initially deal with the **software sector** of traffic control. A useful categorisation of providers appears to be

- major industrial groups with extensive railway businesses, particularly in neighbouring train control and signalling markets, like (in alphabetical order) Alstom, Ansaldo, Bombardier, Invensys, Siemens, Thales and overseas companies like Mitsubishi, Hitachi (Japan) or Marubeni (Korea),

- large, typically multinational IT-companies and system integrators (sometimes also outsourcing-providers) with varying degrees of specialist expertise in the transportation industry, like Accenture, Atos Origin, Cap Gemini, CSC, EDS, Indra, Logica, Steria and others,
- specialists, either with focused experience and skills in the railway sector, e.g. Funkwerk (ex Vossloh) or with functional profiles for cross-industry expertise in databases, real-time communication, software-modelling, web-based solutions or software requirements' management, like again Funkwerk, Telelogic, Tipco, Vivum and many others; the specialists have mainly more of a local exposure, but nethertheless often operate internationally,
- railway infrastructure managers, who are ready to share their proprietary system design or modules/applications as platforms for customisation in other countries. This may occur in joint approaches with the industry but also on a stand-alone basis. ADIF is an infrastructure manager that is in possession of advanced systems and partnering with INDRA, its system provider to market solutions world-wide. SBB is another railway that may consider sharing its solutions with other users.

A recent study of market shares indicates that the supplier-market is currently a European and American one (see figure 8). Overseas supplier from Asia have significant competence in the sector but are much less engaged in European traffic control than in more standardised markets like rolling stock.

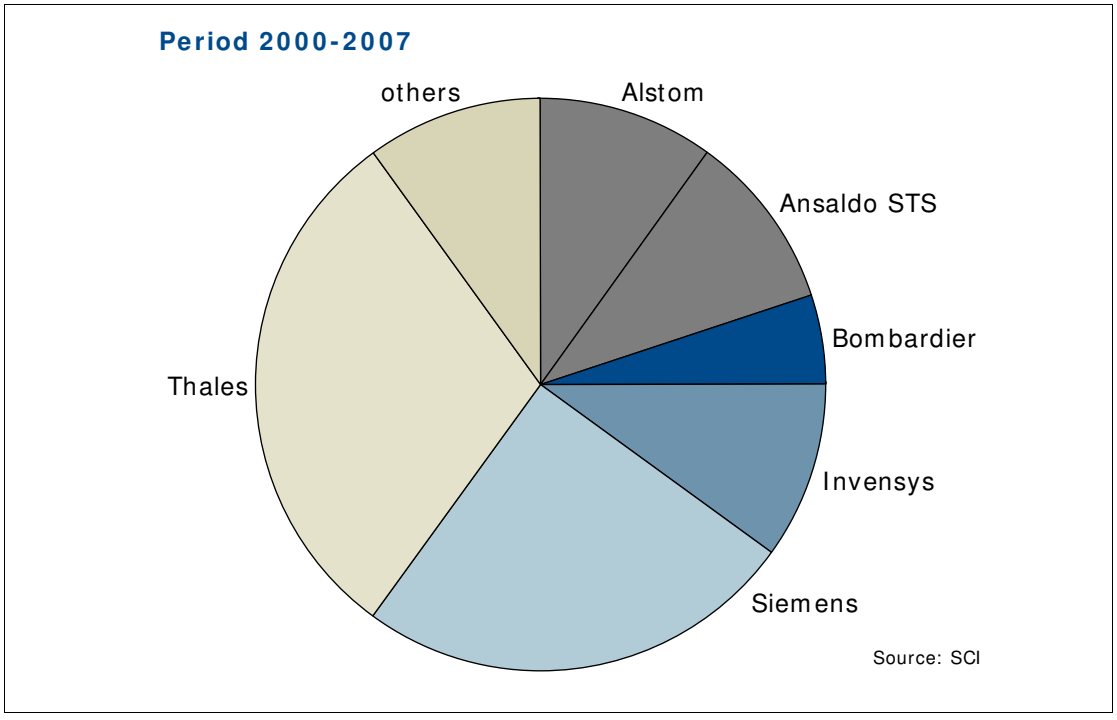

Figure 8 Market shares of system suppliers for traffic control

The identified market-shares cover traffic control hard- and software including networks for data transmission for both European heavy rail and urban rail systems.

The dominant role of the industrial groups is probably influenced by

- its functions as prime contractors; subcontractors for hardware and system integration are not accounted separately in these cases
- major contract values for the rehabilitation of communication networks, which may dominate quantitative analyses.

While a strong market position of these groups can be acknowledged, its role is not as dominant with a specific focus on the software application market as it may appear from an aggregated view on the sector.

Characteristics of the above named companies are presented in the following table 9.

When "products" are mentioned in the portfolio it is important to bear in mind that these are rather concepts (platforms) for individual adaptation on existing system environments than "plug&play"-solutions. For example, the traffic control system "LEIDIS-N" of DB AG is marketed by Thales under the brand name "Aramis". When it has been sold internationally, adaptations have been carried out of "generally spoken some 20%" even for the limited complexities of railways like Israel and Portugal.

Major industrial groups			
Company	**Base**	**Characterisation**	**Portfolio (selection)**
Alstom	France	Global rail transport equipment and service provider Signalling and traffic control segment strengthened by US-acquisition in 2003 (GRS General Railway Signal)	IRIS (Integrated Control Centre) MASTRIA (Automatic Train Control System)
Ansaldo STS	Italy	Diversified industrial company (part of Finmeccanica group); transport telematics are part of the Signal Unit Dutch subholding Ansaldo Signal NV acted as shareholder for the group's foreign operating companies only and was closed in 2008	traffic control systems (with attention on integration) in Italy and world-wide: ERTMS adaptation OTP Optimized Traffic Planner CBTC Communication-Based Traffic Control for Under-ground lines
Bombardier	Canada Transporta-tion head-quarter: Germany	Global leader in rail equipment manufacturing&servicing industry Company centre for customized software development (mainly for turn key projects) based at Gujarat, India	integrated control systems radio block centres software design and maintenance
Invensys	Great Britain	International signalling specialist evolved from a merger of BTR and Siebe Former BTR Rail companies still trade under established names, as Westing-house Signals, Signalling Control UK, Dimetronic Signals	FUTUR (ERTMS system in use e.g. at high speed lines in Spain)
Marubeni	Korea	Overseas firms Competitors/partners of European suppliers world-wide (e.g. consortium Invensys/Marubeni in Taiwan), in European markets no relevant role yet	traffic control applications, for air&rail in Asia (as high speed rail [e.g. Shinkansen] and conventional lines [as China])
Mitsubishi	Japan		
Hitachi	Japan		
Siemens	Germany	Global transportation system provider and key supplier of signalling systems	ILTIS (control system) TRAINGUARD balises, radio control units (ERTMS components)
Thales	France	Leading system supplier since acquisition of the "transportation systems" unit of Alcatel Lucent in 2007	Aramis (comprehensive traffic control system) NetTrac (train control) LockTrac and AITrac (safety)

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Large IT-companies and system integrators			
Company	**Base**	**Characterisation**	**Portfolio (selection)**
Accenture	USA	Global consulting, technology services company with specific rail competence, e.g. on IT-benchmarking/strategy issues	Consultancy, system integration, outsourcing
Cap Gemini	France	Global IT-consultancy emerged from CapGemini and the consultancy unit of Ernst&Young Subsidiary Sogeti currently provides project leader of a main NSR IT-project	Consultancy, system integration;
CSC	USA	Global leader for technology enabled business solutions and services Long-standing experience in the transportation industry	Consultancy, system integration; e.g. in business with NSR for IT service alignments
EDS	USA	Global IT-solution provider with know-how about Dutch systems gained by acquisitions in the 1990th's (CVI from NS and ICIM from Rijkswaterstaat)	Consultancy, system integration;
Indra	Spain	IT-company with competencies in real time control (esp. air, adopted to rail)	DaVinci (traffic control)
Logica	Great Britain	Global IT-provider, experienced e.g. in rail real-time traffic information and monitoring	Consultancy, system integration, e.g. for ProRail-system TROTS (2004)
Steria	France	Leading end-to-end IT services provider for companies and public authorities throughout Europe with considerable experiences in real-time control of transportation systems (mainly aviation)	Consultancy, system integration, e.g. Europtirail (cross-boundary integration of traffic control systems for European freight freeways)
Specialists			
Funkwerk	Germany	Became specialist for communication systems in transportation by acquisition of the information technologies division of Vossloh in 2007	Consultancy, system integration, e.g. RCS for SBB
Telelogic	Sweden	Global solution provider for process automatisation and enterprise service architectures; current take-over by IBM	DOORS (requirements management application, used e.g. at German rail)
Tibco	USA	Global software company focused on service-oriented architecture (SOA), business process management (BPM) and business optimization	Consultancy, system integration
Vivum	USA	software company with focus on asset management and finance software solutions	Consultancy, system integration

Figure 9 Overview of suppliers for traffic control systems

In terms of **hardware equipment**, vendors of standard infrastructure represent (increasingly with the advance of modern software and hardware technology) a vital backbone for modern ICT-solutions. Therefore relevant suppliers consist of the "global players" in this business like Intel, AMD, Motorola and HP for micro-processors and computing or Oracle, Microsoft, Linux etc. for systems.

An overview about the most important suppliers and their characteristics is provided in the following table 10.

Suppliers of servers and semiconductors			
Company	**Base**	**Characterisation**	**Remarks**
ABM	USA	Multinational semiconductor company and second-largest global supplier of microprocessors	Products include embedded processors for servers, workstations and PC
Acer		Asian manufacturer of PC's but also servers	Minor relevant European rail hardware supplier yet
HP Hewlett Packard	USA	Large global manufacturer of computers and servers (hosts)	acquired EDS in 2008 (see figure 9)
IBM	USA	Multinational hardware manufacturer and supplier of hosting services	Global supplier of industrial standard computer equipment
Intel	USA	World largest semiconductor company	
Motorola	USA	International supplier of semiconduc-tors and networks	
Sun Microsystems	USA	Supplier of workstations and servers for many industrial system providers as Alcatel, Siemens	Systems in use world-wide (Europe, US, Asia)
VIA Technologies	Taiwan	Taipeh-based supplier of chips for PC's and networks	Various subsidiaries as Centaur Technologies, S3 Graphics,..

Figure 10 Overview of selected hardware-suppliers for traffic control

Sourcing and maintenance markets are typically also very heterogeneous; the following categorisation appears to be useful:

- Legacy systems at railways (sometimes self-developed) are typically maintained by railways themselves ("in-house").
- New generation systems are often maintained (e.g. with software releases and 24/7-service lines) by the developers.
- Independent/separate maintenance and service providers for mature and well-defined systems get into the market through competitive bidding for the service-component only.

Hence, independent providers of maintenance services are scarce. Services will be offered depending on individual requirements from medium-scale and rather national based companies. Whilst the market-share of independent maintenance providers will be limited, they may play an important role as competitors and benchmarkers for according services from system developers and internal railway entities.

6. Market Trends and Developments

6.1 Demand-side

This chapter will again initially deal with developments at the **software (applications) market**. Secondly, trends related to customers at the hardware market will be highlighted.

Railways' decisions about renewals of traffic control systems are based on **market screenings**. International examples show that these may lead to the result that products or platforms for specific needs of railways are not available on the market yet. This was the case at Swiss Federal Railway SBB, which deemed their 15 year old traffic control system (SURF) not to match current requirements for capacity and availability any more. High standards on consistent real-time data were expected ("bring planning close to operations") in order to enhance system robustness and thereby create additional network-capacity for the very high traffic-density on the Swiss network, which is very comparable to the Dutch situation.

As alternatives for an own development, SBB considered risks and benefits of more fundamental system migration against stepwise updates of single applications and decided to develop a new traffic control system ("Rail Control System", RCS) "from the scratch" (even with a total renewal of the underlying network data by a consistent "Unified Network Objects database") in order to avoid that "more work is spent on interfaces than solving the real problems".

Following to this decision, an important strategic issue is the **degree of industry participation still in early stages of system definition**.

This is considered against the background of dramatic changes that happened in the fast-paced business environment of IT/semiconductor-industries during the last decade regarding the sectors of software and system development tools, procedures and skills as well as migration processes.

State-of-the-art tools like certified "guaranteed system platforms" are provided in a much more all-encompassing fashion by service/system specialists, which also take responsibility for continuous technology adaptation. The critical resource is in the knowledge and specification that keeps providers in touch with developments to an extent, that even the big railways can hardly (or at extremely high costs) be close enough to top-tier developments with internal resources to fully understand how to make the best use of it.

This has been one of the reasons for several European infrastructure managers to integrate supplier know-how into the requirements management of their traffic control systems (as principally shown in figure 11).

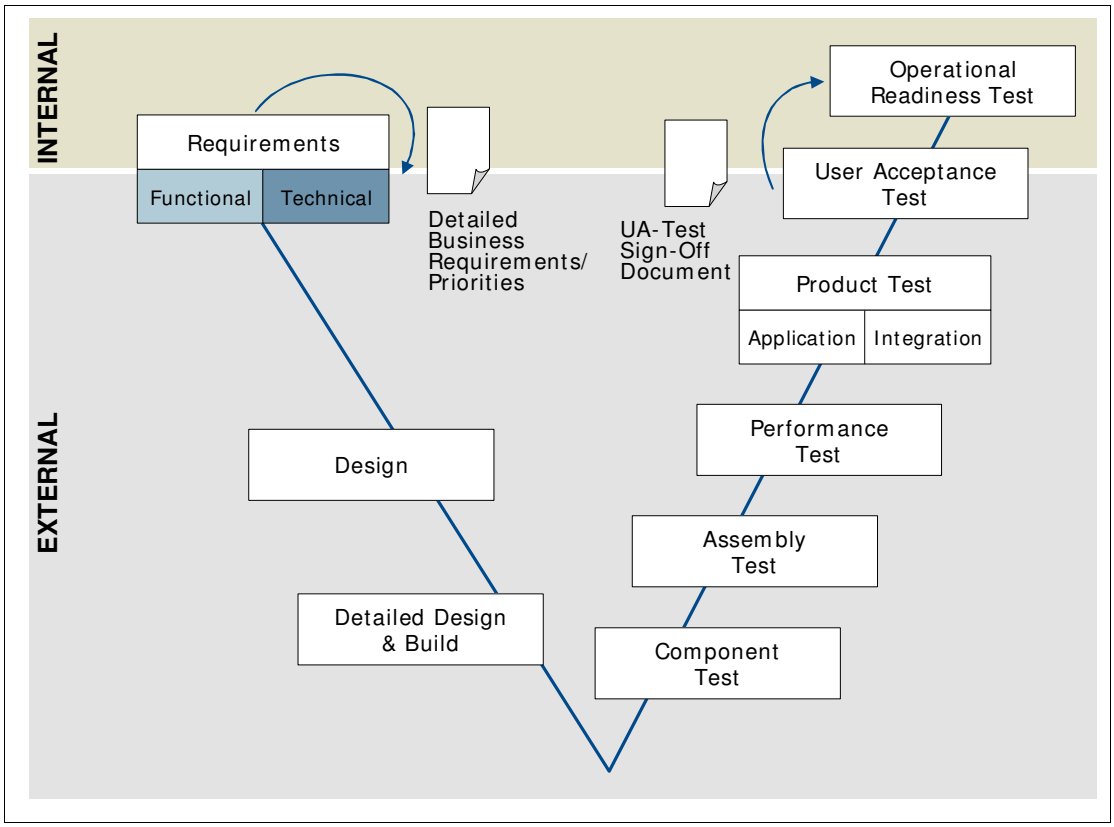

Figure 11 "Integrated Development" Approach

In the case of Switzerland, suppliers perceived that as a chance for an advanced cooperation model, embedding specialist know-how in the phase of defining user requirements, since "clients (i.e. infrastructure managers) often have a very blurred understanding of their own specifications when tendering-out ICT-systems, just reflecting that they did not know in the beginning, what they themselves want".

On the other hand it is unanimously acknowledged that infrastructure managers must not leave the leadership of their system developments to the industry. Therefore external participation in the requirements management has to be carefully considered on the background of system conditions and organisational capacities. The approach requires on the side of the infrastructure managers strong project management capabilities, highly skilled core-competencies on system requirements and specifications as well as sufficient functional and testing expertise to provide and handle detailed, well-documented business priorities. On the side of the suppliers, resources experienced to execute higher complexity are needed. Four out of twelve proposals from the market turned out to be highly qualified in this regard in Switzerland.

After an extensive (1 ½ year long) proof-of-concept in 2005, a consortium of CSC and Funkwerk (previously Vossloh) started work in a joint team with SBB on a tightly controlled time-and-material base. The consortium rolls-out first modules on-time. The result is also considered as a "kind of a product", from which other infrastructure managers could benefit.

A similar example from The Netherlands is the so-called "HIT"-project of NS Reizigers on passenger information. System requirements were pre-defined in the tender only on a high functional level. Details were worked out then in an interactive process between NSR and the supplier (Funkwerk), who contributed his know-how-base and experience from a similar system development in Norway and actively managed the interaction between the related parties.

By doing so, the development process and the integration of end-users was much advanced (results achieved "much quicker and in better quality than in other projects" according to NS). However, in ProRail's view this development at operators' side also shows the relevance of a sounder embedding into the context of existing environments at the infrastructure manager in order to ensure compatibility and successful interaction of systems.

Altogether railways who follow joint approaches with the industry and consequently define (and limit) their roles as a system architecture leader, who creates the vision, defines the main steps, the best partners to get there and controls the process, obtain shares of 80-90% of project efforts from external suppliers.

Initiatives towards **harmonisation and standardisation** of systems were previously rather seen at the supplier side of the market, which has an economic interest to use existing platforms for international sales activities. Despite European efforts for a "top-down"-creation of a common European market no significant initiative was found on the demand-side to promote (or even only support) convergence of national approaches at the traffic control sector. EU-interoperability aspirations are rather a "push" that meets reluctance than a pull by the infrastructure managers themselves.

Nevertheless evidence is strong from the sector of signalling and interlockings, that standardisation and innovation can be successfully implemented by "bottom-up"-approaches, when procurement strategy accounts for a modularisation of systems, brake-up of tender packages and encourages the adaptation of "non-railway" but industrially established technologies.

For instance, Deutsche Bahn AG has pursued such a strategy since 1999 and found that "markets for qualified suppliers are well existing, but in need to be actively managed". After several years of efforts, the number of suppliers for electronic interlockings was increased to six and the number of industrial consortia for operational centres up to three, while comparable systems are procured

now "certainly not less than" 30% cheaper than the original offers of "incumbent suppliers" and with much more compliance to deadlines.

While such coherent strategies were a domain of some "first movers" in the previous decade, initiatives to open up markets are currently a trend at many railways. They expect that "a disclosure and standardisation of interfaces will push transparency and competition, since it allows for specific procurement of single applications and a cost-efficient mix of competitive suppliers" (see DB AG or ADIF).

Open standardised interfaces with proprietary information at the railway (not the supplier) are a key-issue in order to strengthen the buyer's position facing suppliers, enhance compatibility of systems and thereby give more opportunities for suppliers to participate in tenders. However, interviewees also highlighted that the number of different suppliers within a system landscape should not exceed a range "in a single-digit level" in order to keep efforts on interfaces manageable and strengthen allocatability in case of mid-performance.

Such kind of demand-side driven interest may eventually transform the market to a European/global dimension and lend it somewhat more of a product-characteristic in the medium-term. However, experiences clearly indicate the need for infrastructure managers to actively work with ("manage") the market in order to make use of its competitiveness.

With regard to **hardware markets** the importance of absolute flexibility of system architectures to switch to the most recent equipment was highlighted by a majority of interviewees.

"Upward-compatible", scaleable and distributed computing/processing components bases on industry-wide standards enable swift changes to follow and migrate to new technology-generations, since only a very small part of asset inventories will be modernised within maximum windows of 2-3 years until manufactures stop their production of a certain platform and move on. A good example for that are the mobile communication networks for railways (GSM-R), which already went through various technological generation changes.

However there were still observations that "railways and their procurement departments try to oblige their suppliers to guarantee delivery and logistics over the next 30 years. It is like 'going to the museum' after a few years time and of course it is crazy in terms of 'inventories and spare parts' requirements and capital employed".

Such parameters do certainly materially restrict market access of state-of-the-art suppliers. Hence, the issue has been acknowledged by many railways (including ProRail) and steps are taken to overcome it.

6.2 Supply-side

Some specialised suppliers and system integrators express a willingness to advance European market creation and do believe (broadly in consensus) that - underneath specific and individual requirements – fundamental system features are surprisingly similar internationally. Thereby **customizing of platforms and concepts** is considered as a valid and usable option ("the railways just don't go for it").

However, no mature "ready-to-use" products can be expected from the market, yet cost-efficient, industrial standard platforms that can nevertheless accommodate customised applications serving the individual requirements and varying operational needs of railways.

Possibly the leading-edge experience in Europe for a supply-side driven market consolidation (or rather "creation") is the implementation of the traffic control system "DaVinci" in Spain. It is a joint development of the system integrator INDRA and the Spanish infrastructure manager ADIF based on a mission-critical platform already used in air traffic control and adopted according to functional design specifications of ADIF.

This highly integrated system was implemented on the ever growing Spanish high speed lines since 2003 and proved to work – similar to its equivalent in aviation - with extremely high availability ("there have been no perturbations up to now which had any effects on train operations").

An additional implementation on the conventional Spanish network is under consideration. Furthermore, the system was bought and is being installed (or considered) in a number of railway systems in Europe (Transport for London) and globally (South America, China). Various other European railways (as the Portuguese REFER, British Network Rail, Austrian ÖBB and Russian RZD) have inquired about DaVinci and appear to consider it as an advanced solution transferable into their own operational environment.

Cross-fertilisation with other industries related to real-time traffic control may lead to the entry of further market participants, which introduce open standards from sectors like air traffic control, where development has progressed in much earlier stages (possibly with a 10-15 year time log).

Major industrial groups with extensive railway businesses are expected to get under pressure in the context of these developments. Some still appear to try to tie-in customers into application families with proprietary knowledge barriers, while the general market view is that they will find it increasingly hard to provide and cover enough width and depth of applications for their clients.

At the same time they have to acknowledge that the overall client base ("market size") is very limited and ICT-solutions are rather "by-products" which typically only account for a very small fraction of sales compared to train control and signalling for instance. This leads to constellations as the rail-control-centre development consortium between Siemens and Funkwerk for DB AG, in which Funkwerk holds the lead [!] for system development.

Hence it can be expected that in the near future some **industrial groups may make strategic choices** to either abandon ICT (or leave it to business-partners) or to shift their own approach to open architectures.

7. Implications for ProRail

ProRail is facing the challenge to bring its ICT for traffic control, which is based on legacy systems, into a more robust configuration and at the same time manage the transition into the future.

In the context of its current system landscape and previous outsourcing of key-experts, ProRail is still bound to incumbent suppliers. In parallel it has already taken various steps which can be considered as a move into the right direction, namely

- to (re-)insource know-how about system-requirements and engineering,
- thus, to reduce exposure to/dependability from tied-in suppliers and service providers,
- to address a programme of priorities for application redesigns,
- to tender-out software-factory work under the umbrella of this programme competitively and internationally,
- to bring the resources of "Tribase" under direct management control of a dedicated ProRail unit (BNS),
- to establish an enterprise architecture platform ("service bus") for better system integration and
- to install a redundant and centralised ICT-operations control-centre in order to enhance infrastructural provisions for business continuity in case of failures.

However, ProRail has undertaken this move some two years ago and is in ongoing efforts to stabilise the situation ("fire-fighting").

The current transitory situation makes an effort to recover from imminent risks of system manageability and robustness and price-worthiness.

Impacts of dependency from incumbent suppliers can be estimated on the base of examples from railways, which went through similar transition processes some years ago. Experiences clearly show, that international suppliers with proven experience in the use of modern technologies turned out to be more competitive as to:

- Performance: state-of-the-art platforms can be expected to work practically failure-proof (see Spain),
- Delivery-speed: Requirements and deadlines are handled more strict (see NSR, "HIT") Price levels: reductions of up to 30% compared to original levels of "incumbent suppliers" were observed (see DB AG and results from pilot tenders at ProRail (which were contracted for the half of anticipated budgets),
- Capacity: advanced systems enable a higher quality of train-operation, which results in a more dense exploitation of networks. SBB expectations on its new traffic control system are capacity gains of 5%.

While a set of actions already taken by ProRail tackle important issues of a future-proof system architecture and accordant market approaches to benefit from these effects, it should be continued and enhanced with explicit considerations towards

- a coherent performance-assured system architecture
- a leap to modern software and hardware technology and tools with inherent advantages of unit-cost digression and standard "times-to-application"
- access system rules and specifications in a self-critical manner under value-analysis aspects
- assure a systematic and robust access to highly specialised professional skills in the market
- continuous evolution of hard- and software in line with technological changes supporting the system functionality in a smooth upward-compatible manner
- consistently managed 24/7 system availability and service/maintenance.

In order to contribute to a generation-change of systems within the VPT-landscape, there is the need to formalise and formulate operational requirements and to determine a level of "innovation leadership" between top-tier developments of technology and successfully proven practices.

Since such system engineering skills are scarce and top-talent is with "attractive" industries as telecom or financial services, there are considerable doubts that even the bigger European infrastructure managers have the critical mass to develop this knowledge in-house (to reasonable costs).

Thus, since the drive of ProRail to do all system design and specification work in-house can be understood as a reaction to currently felt and pressing needs to establish respectively restore an internal knowledge-base, it appears to go too far and should be better balanced with the market.

International good practice suggests that - starting now and with a longer-term perspective - ProRail needs to consequently develop its approach to the whole procurement issue and its business-model to interact with the market by considering at least the following elements:

(1)

Continue on the re-building of a highly skilled knowledge-base within ProRail, that has **sovereign** insight and mastery of the **railway-operational processes** and rules; this "centre of expertise" should consider itself as system experts for the operation of traffic and networks, **not** as a technology-focused team. It should resource appropriate technologies (as a means to an end) from the market for this purpose, it might rethink its human resource strategy in order to attract some very top experts.

(2)

Continue to reassemble and formalise lost or hidden operational and safety procedures as the prime and foremost task of this "centre of expertise" in order to establish a solid foundation for all future (and current) "**requirements management**" (i.e. a thorough definition of specifications), as it is good-practice for system development in advanced industries (like aviation, automotive, financial services).

(3)

Continue to establish such a **professional "requirements management"** in cooperation with specialised IT-advisors and the support of modern tools in order to enhance benefits which have already been seen from efforts of the last two years in

- higher efficiency,
- an induced formal rigour to define specifications comprehensively and contradiction-free
- a generic set-up to automatically derive a testing-environment for software and hardware components
- some cross-fertilisation between railway-specific aspects and
- an up-to-date wider knowledge from other industries.

(4)

As a further step, and building on the previous one, this "centre of expertise" should embark on a **self-critical assessment of rules and specifications** with regard to value-added and/or necessary mastery of forgotten (often unreflected) underlying background for solutions and system design.

(5)

ProRail should adjust (in parallel) a **procurement strategy**, that

- packages applications and tasks into a limited number of lots, transferring responsibility for functioning interfaces to a greater extent to suppliers
- puts these packages out in the market for competitive international tendering among top-providers from the industry
- considers to develop mission-critical systems, in case that markets do not offer sufficient platforms, to implementation-stage (on a paid-for basis) in parallel by two suppliers for competitive and fall-back reasons, like e.g. the US Department of Defence (DOD) does for new aircraft
- puts (far greater) emphasis in pricing on **achieved** performance standards or similar objectives of the respective business cases behind the projects
- (as a development step) combines the delivery and implementation of an application with longer term service contracts, ideally covering 24/7 operations, service, release management and underlying migration of hardware/software-components in line with technological changes.

(6)

As a starting-point for the technical assessment of the current ICT-system landscape, ProRail should mandate an **ICT-screening** with regard to

- modernity/obsolescence of hard- and software
- internal/external system development capabilities
- future industry "musts" and opportunities

(7)

By this screening, ProRail should gain a structured overview on generic applications, platforms and tools from other industries and also further evaluate potential templates from advanced peer railways, leading into an overall strategy (or **masterplan**) how to develop the ICT-landscape further and transpose it into a future generation.

(8)

Based on some of the before-mentioned steps ProRail may eventually decide about **further stages of outsourcing** of system-operations, continuous development and technology management.

(9)

Railway operational expertise and "**Requirements Management**" remains a core capability for ProRail that is unsuitable for external sourcing. The current effort to overcome the brain-drain should lead to a well-formalised knowledge-base built with further enhanced use of up-to-date and market going modelling tools.

8. Conclusions

The key-questions of the market-analysis can be summarised in the following statements:

- "Which are the relevant markets (both in terms of products and geography) that serve ProRail to obtain their products and services for ICT systems in traffic control?"

  The relevant market for software development consists of companies which may be generally based internationally. However, it turned out that presence in The Netherlands is of great advantage, since close contact to the customer and Dutch speaking staff is required.

  On the hardware-side, the relevant market is global and covers all effective suppliers of business computing.

- "How important is the differentiation between hardware for installation and operation of ICT-systems on the one hand and software for system development and maintenance on the other?"

  The differentiation is important since the grade of explanation and customisation requirements for products differs significantly. Since the hardware market is much more standardised, less interaction with the customer is necessary. This makes it easier to procure and deliver globally.

- "Who – explicitly – are the suppliers and customers? To what extent do they act domestically or internationally?"

  Suppliers are provided at figures 9 and 10 of this report, customers (by countries) in figure 7. While the demand-side – which mainly consists of state-owned railways and infrastructure managers - is still relatively domestic in its nature, most suppliers act on a (at least) European scale.

- "Which significant developments and trends can be identified and what is their potential impact on the effectiveness of the market, e.g. possible entries and exits of market players?"

  Supplier know-how is going to be increasingly integrated into early phases of the requirements management of traffic control systems by joint-approaches towards system developments.

  Harmonisation and standardisation of systems, which are still in its infancy despite of much European efforts, support the effectiveness of the markets, since similar industrial concepts or system platforms (however adopted) are used internationally.

  Industrial groups, who try to tie-in their customer into proprietary knowledge barriers, are thereby under pressure. Some may make strategic choices to either abandon ICT (or leave it to business-partners) or to shift their own approach to open architectures.

  Cross-fertilisation with other industries may lead to the entry of further market participants with competencies in real-time traffic control (as from aviation).

- "What are entry barriers for the various sub-markets, e.g. intellectual property rights or governmental regulations?"

  For software (application) markets, barriers to participate on tender procedures cover

  - the degree of technical rather than functional specifications, which may formally exclude even functional adequate solutions
  - proprietary information on interface standards which are essential to connect a system with others within an existing architecture.

  For hardware markets, some railways still restrict the market by requirements for guaranteed delivery and logistics periods, which are much longer than the life-time of a hardware platform in the fast-paced technological environment.

  This urges suppliers to support outdated technology and thereby limits the number of market participants.

- "How compatible are components and services provided by different suppliers? How important is compatibility for the effectiveness of the market? Which risks can be identified and how can they be mitigated?"

  A trend towards standardised platforms and open interfaces (however in its infancy yet) supports compatibility, since suppliers are able for customising applications onto different environments, if they are in charge of the

necessary information for it. This will give more opportunities for suppliers to participate in tenders.

However, too many different suppliers may be a risk for the system management in case of perturbations. Thereby the number of suppliers within a system should be restricted "on a single-scale level".

- "How do current procurement and contracting practices impact prices and the speed of delivery? What can be done to improve market-effectiveness? What can be learned by other infrastructure managers internationally in this respect?"

  Impacts of dependency from incumbent suppliers can be estimated on the base of experiences from railways, which already successfully widened their market: 30-50% higher prices, less strict handling of delivery-times and lower system performance which leads to less capacity on the network.

  Thereby ProRail needs to go further steps onto its way to make full use of the marked (as described in nine recommendations at chapter 7).

  Necessary key-resources need to be developed, while ProRail has to prevent itself from a fall-back into overly excessive inhouse-strategies.