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Dealing with standardization in liberalized network industries: Some lessons from the European railway sector

Dr. Marc Laperrouza[1] & Prof. Matthias Finger

Ecole Polytechnique Fédérale de Lausanne
EPFL-CDM-MIR, Château de Bassenges, Station 5
CH-1015 Lausanne, Switzerland

Abstract

The European railway sector is undergoing dramatic changes. During the still ongoing liberalization process most vertically-integrated railway operators have already been "unbundled". The shift from integrated to disintegrated companies coupled with the introduction of competition – so far in freight, but as of 2010 also in international passenger traffic – is having profound implications on the development and deployment of new technologies. In addition, within the framework of the Single European Market the main stakeholders have now to work under the constraint of interoperability.

The paper examines railway standardization processes within an interoperable environment. So far, the railway sector has a strong history of national standards development. In the area of signalling, the result and current situation is therefore a patchwork of poorly interoperable systems. The paper builds on a case study of the development and deployment of a core signalling system – the European Rail Train Management System (ERTMS) – to illustrate the difficulties to coordinate a standardization process in such a deregulated environment. The paper questions whether, in the framework of the emerging technological and institutional environment, the current governance of rail standards is suited to the EU's objectives of a competitive railway market.

Through the introduction of ERTMS the paper discusses the role of the new European Rail Agency (ERA) as the locus for coordinating the ERTMS standardization process. It makes recommendations as to which actor(s) is/are best suited to govern the standardization of such highly complex and interdependent technical systems.

Keywords: railway liberalisation, institutions, technology, standards

[1] Corresponding author. marc.laperrouza@epfl.ch

Introduction

Like most network industries, European railways are subject to intense liberalization pressures. During the past decade, most countries have launched into the separation of train operations, infrastructure management and path allocation. In addition, and sometimes in parallel, they have introduced competition in a number of market segments (e.g. freight and regional lines) and are preparing for the future opening of the international passenger market[2].

The overhaul of the European railway market has, by-and-large, been driven by the Commission's 2001 Transport White Paper (European Commission, 2001). But the Commission's attempt to create a competitive "Single Railway Market" has met with a number of difficulties. Railway systems have historically been run at the national level through vertically-integrated monopolistic and state-owned companies. Not surprisingly, these different national railway networks have been designed under different operating rules and philosophies. This resulted in a lack of interoperability which can be observed in different types of track gauges, different types of electrical power supply, differences in speed control, train safety technologies, as well as different job profiles for drivers. Today, crossing national borders remains impossible for many trains for technical and operational reasons. For the time being, the solution to running international trains across different railway systems lies in multiplying the on-board train equipment so that the locomotives can cross borders, as well as training drivers to conduct trains under different operational rules[3].

The European Commission's ambition to foster a competitive pan-European railway market rests partly on improving the interoperability of the heterogeneous national railway systems. To this end, it has been encouraging the development and deployment of a harmonized railway management system – the European Rail Train Management System (ERTMS) – across Member States. Despite similar external pressures, like the on-going liberalization process of the European railway market and the creation of a pan-European Railway Agency (ERA), national policy responses to and actual deployment of ERTMS differ widely and remain well below expectations. The European Commission (EC) resorted to appointing a special ERTMS coordinator to speed up and extend the current deployment of ERTMS.

The paper presents a case study around ERTMS, one of the most important technological development in railway's recent history and a cornerstone in the EC's interoperability objective. It builds both on secondary literature – ERA reports, stakeholder publications (CER, EIM, UNIFE, RUs, TOs, etc.) – and on high-level interviews conducted with the main stakeholders in the railway sector (ERA, railway associations, railway undertakings, infrastructure managers and national transport ministries). It is part of a larger research project dealing with the co-evolution between technologies and institutions.

The paper argues that the successful transition from a regulated to a liberalized environment causes and necessitates institutional transformations that go well beyond the creation of a regulator or the licensing of new entrants. This is particular true of most networked systems with a strong technical/technological component. Fulfilling the market liberalization objective – measured by the creation of a competitive and performing market – actually requires the alignment of technology and institutions.

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2 The 3rd railway package proposed the opening of international rail passenger transport by 2010.

3 Multi-system locomotives already ensure reliable rail transport (e.g. the Thalys between France and Germany or the Cisalpino between Italy and Switzerland).

There has been a recent resurgence of interest in understanding how the interplay of regulation and institutions applies to network industries and more particularly how it affects performance (Andres, Guasch et al., 2007)[4]. In Europe, the renewed interest can in large part be explained by the fact that many utilities – including railways – used to be monopolistic and vertically-integrated. Driven by market liberalization the unbundling of activities (e.g. infrastructure management and train operations) creates a fundamentally different dynamic in infrastructure sectors. So far, most of the discussion about the liberalization of railways industries in Europe has centered on measuring aspects of economic performance (Spychalski and Swan, 2004; Jupe and Crompton, 2006)[5]. For instance, the issue of railway interoperability received scant attention[6]. Grillo (2002) argues that networks will never be perfectly interoperable. He proposes that interoperability should be defined as “the result of an assessment of a combination of technical, organizational and regulatory factors”. Similarly Rothengatter (2006), while acknowledging the technical element of interoperability, highlights the importance of the associated rules of control and management. Even if the technical effectiveness of particular railway technologies is largely covered in the technical literature, the issue of system-wide performance (i.e. the economic-societal-technical nexus) of the railway system is seldom discussed.

One strand of literature has introduced a promising theoretical framework to analyze this relationship between technologies and institutions and how it affects the performance in network industries. In their seminal paper on coherence/co-evolution between institutions and technologies, Finger, Groenewegen et al. (2005) distinguish between three categories of infrastructure performance: economic performance, public value, and technical integrity. Economic performance is further divided into price efficiency, dynamic efficiency and system efficiency[7].The main argument put forward by Finger, Groenewegen et al. is that ensuring satisfactory functioning of any infrastructure requires coherence between the technical and institutional governance – both technical and institutional coordination are ensured via centralized, decentralized or peer-to-peer coordination mechanisms[8]. The notion of “co-evolution” between institutions and technology can appear counter-intuitive[9]. On one side technology tends to be market-driven, un-predictable and evolving rapidly. On the other side institutions tend to be “government-driven” (or government-laden) and to exhibit strong path dependency – making them prone to a relative inertia. It is precisely this opposition that creates a tension and potential for failure in the development and deployment of a new technology. It is this tension which impacts the performance of networked systems.

While applying their theory to the electricity and air transport sector, the model proposed by Finger et al. remains at a relatively high level of abstraction. In a subsequent article Künneke and Finger (2007) argue that, in the era of liberalization, certain critical technical functions need to be supported by suitable institutional arrangements in order to safeguard a satisfactory

[4] They argue that the structure, institutions, and procedures of regulation matter for infrastructure sector performance.

[5] Even there, the measure of railway performance is too often reduced to punctuality!

[6] In an early paper (Nijkamp, 1995) had called for European cooperation to create interoperable networks.

[7] Dynamic efficiency is understood as the ability of the economic system to stimulate and initiate innovations that enhance productivity. Public value incorporates the idea of consumer and public interest whereas technical integrity is understood as the capacity of a system that is in some kind of distress, to resist or adapt to this situation in order to maintain an acceptable level of performance.

[8] More precisely, the *degree* of coherence between the technical and the institutional coordination of a network’s major functions – interconnection, interoperability, capacity and system management – determines performance.

[9] For a discussion on the concept of co-evolution in large systems, see (Schneider and Werle, 1998).

technical functioning. They call for the alignment of technological and institutional regimes into a coherent framework, which is not too far from Von Tunzelmann (2003) calling for a generalization of interrelationships between technological and organizational change over the longer term – in his argument, the network alignment is suggested as a means for bringing about the co-evolution of governance and technology in development processes.

Theoretically, the paper borrows from historical institutionalism (HI). The railway sector is particularly well suited to a historical institutional analysis since it is strongly driven by government/institutional policies – most European governments consider railways as a public good. It also exhibits a strong tendency to path-dependency. Several authors have used HI as an analytical lens to study the sector (Dunlavy, 1992; Lodge, 2002; Dobbin, 2004). For example, the study of the reform of British and French railway regulation (Lodge, 2003) shows that the structure of the political-administrative nexus centrally shaped why particular policy options were selected while others were neglected. As noted above, the paper draws on a second body of literature investigating the relationship between technology and institutions and its impact on performance[10].

In the first part we review the European efforts at creating a single rail market, introduce the notion of interoperability, and sketch out a brief history of ERTMS. The second part of the paper questions whether the current European institutional arrangement is well suited to develop, deploy and maintain a pan-European standard in a liberalized railway market. Particular attention is given to the role of ERA in the deployment of ERTMS.

Part I – Towards a Single European Railway Market

In 1991 the European Union (EU) started a reform program to make railway industry more economic and efficient (Directive 91/440). The program had three major components: separate railways from the State and establish them as commercial undertakings, divide monopolistic (infrastructure) from contestable (train operations) railway activities and regulate networks to prevent abuse. The EU pushed its agenda through a number of railway packages. A first legislative package dealt with organizational separation, licensing regimes for railway undertakings and regulation of infrastructure. It was followed in 2004 by a second package aimed mostly at legal and technical integration; it included the establishment of a railway agency (ERA) and the passing of rail safety regulations[11]. In November 2007, the European Parliament and the Council of Transport Ministers adopted the legislative proposals of a third package consisting of measures relative to market opening for international rail passenger services, rail passenger rights and obligations as well as the certification of train drivers.

Interoperability

The adoption of these three legislative packages aims at creating a competitive European railway sector. However experience from the liberalization of other network industries (e.g. electricity or telecommunication) has shown the negative effects of insufficient access to the network on the competitive situation in the respective sectors. Not surprisingly, one of the greatest challenges in the liberalization of Europe's railway market is ensuring the non-discriminatory and transparent access to the network and other infrastructure facilities. One of

[10] See Finger et al..

[11] There is a time lag between the adoption of a railway package at the EU level and its implementation in the different countries. See Table 1 for transposition of EU railway interoperability into national legislations.

the central elements facilitating access to a networked system – and thus making competition in the market possible in the first place – is technical interoperability.

In the European railway context interoperability has been mandated by two EU Directives[12]. The first one (Directive 96/48/EC) was passed in 1996 and only concerned the interoperability of the trans-European high-speed rail system. The second one (Directive 2001/16/EC) applied to lines within trans-European transport networks and to the rolling stock operating on these lines. These directives formally define interoperability as "*the ability of the trans-European rail system to allow the safe and uninterrupted movement of trains which accomplish the specified levels of performance. This ability rests on all the regulatory, technical and operational conditions which must be met in order to satisfy the essential requirements*". A further step towards interoperability was achieved through the passing of the second railway package in 2004 – a Directive for the harmonization of safety requirements and certifications that were different in all Member States, and a regulation for the creation of a European Railway Agency (ERA) for Safety and Interoperability[13]. The need for such an agency arose from the magnitude, the scope and the nature of the problems that the European railway system faces in a liberalized business environment.

Table 1: EU railway interoperability legislation implementation in selected EU countries

Interoperability Directives	NL	DE	BE	FR	ES	IT
Directive 96/48/EC	1999	1999	2000	2001	2000	2001
Directive 2001/16	2003	2004	2003	2005	2003	2004

Source: Compiled from EU website on interoperability http://ec.europa.eu/transport/rail/countries/index_en.htm
Note: Directive 96/48/EC deals with high speed rail and Directive 2001/16 deals with the trans-European conventional rail system. Implementation was required by April 2003.

In order to achieve the objectives of these directives, technical specifications for interoperability (TSIs) were initially drawn up by the European Association for Railway Interoperability (AEIF), which acted as the joint representative body defined in the directive before the creation of ERA[14]. The working method established to produce the required technical harmonization consists of defining the necessary minimum in terms of each sub-system, by entrusting a joint representative body (ERA) with the task of preparing Technical Specifications for Interoperability (TSIs). The interoperability directives put into place a system for conformity assessment against technical specifications for interoperability (TSIs), the placing into service of subsystems, and the placing of interoperability constituents onto the market. The roles of the key actors and bodies are established such as notified bodies, contracting entities and supervisory authorities[15]. Further, the directives mandated the

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[12] Directive 96/48/EC of 23 July 1996 (OJ L235 of 17 September 1996) and Directive 2001/16/EC of 19 March 2001 (OJ L 110 of 20 April 2001).The Interoperability Directive 96/48/EC Article 4(1) required that the trans-European high-speed rail system, subsystems and the interoperability constituents including interfaces meet the essential requirements set out in general terms in Annex III to the Directive. The essential requirements were: safety, reliability and availability, health, environmental protection and technical compatibility. The Directive allowed that the essential requirements may be applied to the whole trans-European high-speed rail system or be specific to each subsystem and its interoperability constituents.

[13] Directive 2004/50/EC of 29 April 2004 (OJ L164 of 30 April 2004) modified Directives 96/48/EC and 2001/16/EC: it updated the provisions of these two directives in line with the directive on safety and the role of ERA and stated the principle of interoperability for the whole railway system, to be implemented progressively as of 2008.

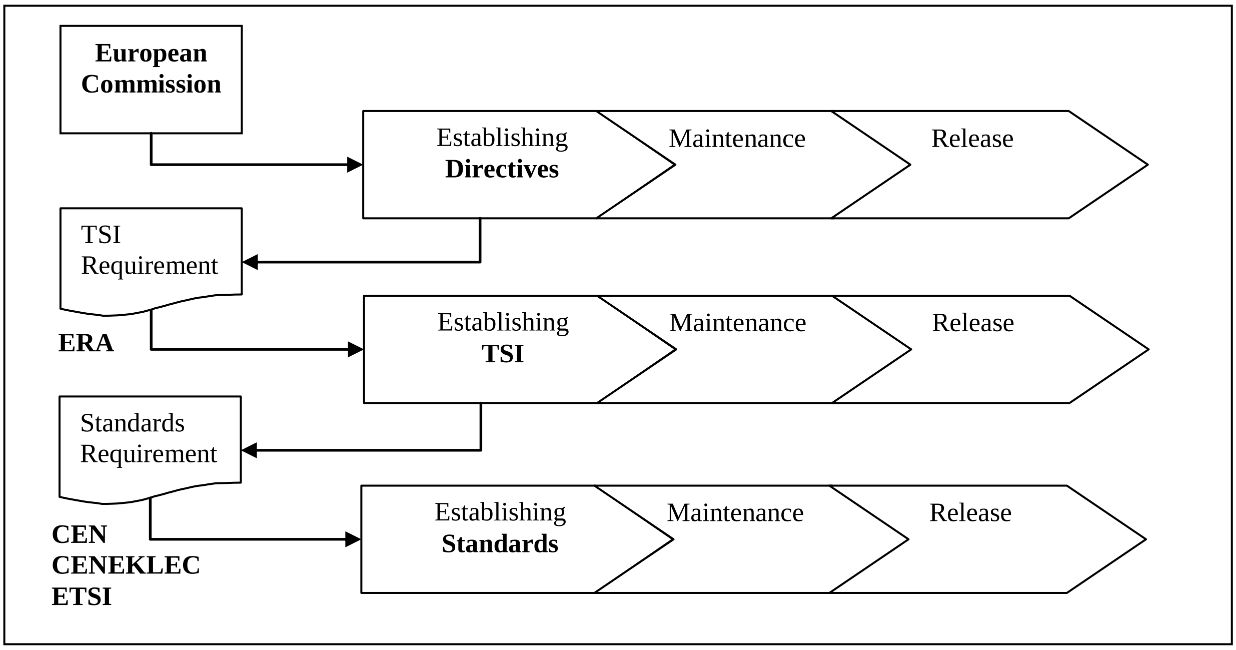
[14] Two EC decisions formally mandated ERA for developing technical specifications for interoperability (Commission decision C(2007) 3371 final – 13 July 2007 and C(2006) 124 final – 9 February 2006.

[15] This section draws on (Kema-RTC DHV B.V., 2007: 10).

development of TSIs which establish the technical interoperability requirements which subsystems and interoperability constituents shall meet[16]. The Commission has adopted in May 2002 the TSI for 6 subsystems – maintenance, control and command, infrastructure, energy, rolling stock, operation. Most TSIs published so far concern high-speed rail[17]. However, according to (Kema-RTC DHV B.V., 2007) confusion about the definition of interoperability and other reasons make the application of the TSIs seemingly difficult and create openings to continue to apply national approaches (TSIs are full of back doors). Further development of the TSIs, aimed at improving their completeness and ease of application is needed to reduce this trend for national solutions.

The European railway interoperability is based on a triple-layer structure: 1) the two interoperability directives (Interoperability Directives 96/48 and 2001/16), 2) the technical specifications for interoperability (TSI) and 3) European specifications, e.g. CENELEC or ETSI norms (see Fig 1.). Directives and TSIs once approved are mandatory and have to be complied with. European standards are voluntary documents unless directly referred to in Directives or TSIs. In practice the Interoperability Directives added a layer – the TSIs – between the EC Directives and the EN standards.

Figure 1: From directives to standards in the European railway sector



Source: ???
Note: Directives and TSI's once approved are mandatory and have to be complied with. European standards are voluntary documents unless directly referred to in Directives or TSI's. Operational rules are usually mandatory

History of the European Rail Traffic Management System (ERTMS)
For a variety of reasons, different automatic train protection (ATP) systems have emerged

[16] For some ETCS is viewed as an add-on project financed by the EC (and wanted by the sector) which found its way into the TSI to make sure it could be enforced.

[17] In April 2008 the Commission has adopted a Decision modifying Annex A to Decision 2006/679/EC of March 2006 concerning the TSI relating to the control-command and signaling subsystem of the trans-European conventional rail system and Annex A to Decision 2006/860/EC of 7 November 2006 concerning the TSI relating to the control-command and signaling subsystem of the trans-European high speed rail system.

across Europe at different times. These systems were, by-and-large, incompatible and not interoperable with each other (Bloomfield, 2006). While most of European railways protect their rail traffic by means of intermittent automatic train running control systems, the operating philosophy of these systems frequently differs considerably from one country to another (resulting for example in speed restrictions). This has left no option but to switch from one control systems to another on cross-border traffic (e.g. by equipping locomotives with multiple systems), or, as happens in most cases, to change the locomotive and the driver.

As early as 1991 the European Institute for Railway Research (ERRI) began examining the idea of a new European train protection and train control system (Project name A200) on behalf of the International Union of Railways (UIC)[18]. From 1990 to 1996/7 most work took place at the functional and technical level – basically among the railways[19]. During this "study and specification phase" a so-called ERTMS users group (EEIG) was created in 1995 by the German, French and Italians – later it was extended to the Spanish, the Dutch and British. Industry joined in 1996 via a consortium of signaling suppliers (EUROSIG). The second phase saw the development of the first products as well as testing and homologation. The third and most recent phase has been concerned with the standardization and actual deployment of the technology. In 2000, the standardization partners (represented by all participating railways in the UIC , the ERTMS Users Group and Europe's leading rail engineering companies grouped together in UNISIG), signed an outline agreement for the introduction of a standardized, interoperable train control and protection system (i.e. with the aim of completing the ERTMS specifications). Member states agreed to publish these precise specifications in the form of a Commission resolution, thus creating a provisional legal and planning framework.

Table 2: Phases of ERTMS project

	Studies and specifications 1989-1997	**Final specifications 1998-2004**	**Roll-out 2004-2008 (till 2020)**
Technical level		Class P to Class 1 SRS	SRS 2.2.2 and 2.3.0 Work on 3.0.0
Institutional level	Directive 96/48/EC	Directive 2001/16/EC	Directive 2004/50/EC
Main stakeholders	EEIG, ERRI, EUROSIG	UNISIG, Railways, CENELEC, AEIF	ERA, Railways
Emphasis	**Engineering**	**Politics**	**Financial**

Source: Adapted from UIC and Winter (2007) and personal interviews.

For the first 10 years of its life ERTMS was politically driven by the European Commission trying to force the national railway companies to work together to deliver the technology – organizations such as the UIC tended to be politically rather than business-oriented in their decision-making. Without strong political influence, ERTMS could have stopped at the end of the first phase (three levels of applications were described in a document called project declaration; there was also quite a deep elaboration of a first set of technical specifications). Individual countries played an ambiguous role. For instance, the roll-out of high-speed lines (dictated by domestic political agendas) created conflicts with harmonization and standardization work (e.g. SRS specifications). At the same time, one has to recognize that these same countries (e.g. Spain and Italy) managed to maintain the necessary overall momentum through their high-speed projects.

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[18] Train control is an important part of any railway operations management system.

[19] Ironically, the task now is to remove some of the early ERTMS options because they create mismatches and to be much more precise about the specifications.

Over the years ERTMS moved from its initial objective to improve technical interoperability in the field of ATP to bringing together multiple streams of harmonization and standardization activities in the areas of signaling and command/control, telecommunications and traffic management. It consists now of two complementary systems: a communication standard (GSM-R[20]) and a European Train Control System (ETCS). Initially, ERTMS was primarily safety and technology-orientated. More recently, work on the third component – INNESS – has been undertaken looking into feasibility of implementing pan-European traffic management systems.

Today, the ERTMS project serves three purposes: 1) improved interoperability of the trans-European rail network – not only inside the EU borders, but also foreseeing the longer term integration of Central and Eastern European networks; 2) the creation of a single market for procurement, leading to a significant reduction in equipment costs and an improvement in the competitive position of the railway supply industry on world markets; 3) the optimization of rail operations on a European-wide scale. As such, it plays a critical role in Europe’s railway market liberalization plan. While the ultimate goal of ERTMS is to ensure the interoperability of cross-border transport, its “side-benefits” are numerous: better and safer working conditions for train drivers, savings for railway undertakings – different signaling systems for various networks are no longer required in the cab – and increase the capacity utilization of the existing rail network – up to 20% increase of capacity through higher speeds and reduced headways.

Deployment of ERTMS in Europe
Under the current migration strategies proposed by the European countries, full deployment of ERTMS – and thus interoperability at the European level – is likely to take several years if not decades. For example, Switzerland who leads deployment in Europe aims to complete the equipment of its network with ETCS level 1 (with limited supervision) earliest by 2012[21]. The rest of Europe is looking towards 2020. In the meantime, the technology will keep evolving: in other words, the long deployment horizon of ETCS poses an additional challenge to maintaining and improving a pan-European standard. According to the British office of Rail Regulation (2004) the deployment of ERTMS faces three problems are threefold: 1) overcoming the initial cost barrier of fitting large numbers of vehicles, so that the network performance and infrastructure cost reduction benefits can be realized[22], 2) managing the major operational change that such a system represents, and 3) overcoming the “reliability trough” that a new system of this kind almost inevitably goes through, before long term benefits start to be delivered.

In reality, a far larger number of technical and operational issues plague a widespread development of ERTMS in Europe (see appendix 1). This can partly be explained by the fact that the various stakeholders within the railway sector – infrastructure managers, train operators, equipment suppliers but also government agencies – hold different views and

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[20] The GSM-R radio system exchanges information between the ground and the locomotive.

[21] This project is known as ETCS-Netz. According to estimates, the equipment with ETCS level 1 of the entire Swiss network (more than 3’000 km) should cost CHF 350 million. Equipment with level 2 would run in billions because interlockings need to be changed.

[22] Cost estimates for the system remain vague and countries have different migration strategies. Some of the old functioning systems are still a long way from the end of their useful lifetime. As lines and the locomotive both have to be equipped with ETCS, trains will in the interim period have to provide service on the established system and in parallel have to adopt ETCS. The EC estimates that the cost of retrofitting would be significantly - up to 80% - higher than the cost of directly installing the systems when constructing new track or upgrading track.

respond to different incentives. For instance, modularization was not a priority for industry (market protection) during many decades. In addition, because of the financial loses incurred on the pilot lines, suppliers are not very motivated to make more research work for new issues of specifications – as long as they have not recuperated their "investment". Safety people have shown resistance to ETCS level 1 with limited supervision (the migration path chosen by Switzerland and Germany) – they want full supervision. Not surprisingly, top management of incumbent railway operators does not always heartily support the ERTMS project because of its essential contribution to market opening[23]. For many of them, ERTMS is "just another system" not yet able to replace the current system[24]. Railway undertakings (RUs) have to deal with a number of version upgrades and backward compatibility issues. In addition, for freight operators, the business case is not as clear as for international passenger transport. The control of standards is in the hands of industry and of infrastructure managers. RUs are weak when in comes to standardization: 1) historically IMs were in charge, 2) they are new in the game and they have to find their role. RUs have to deal with a complex system which used to be taken care of by IMs; in addition they have to deal with maintenance issues. RUs haven't yet realized they have to take part in the development of ERTMS since part of the responsibility is being put on the train. In other words, ERTMS is no longer a black box for the TOs (it requires maintenance and configuration management) even if with ERTMS, responsibility is shifted from the engine driver to the system.

In summary, the path to a single European rail market is fraught with difficulties. Despite efforts from the EC to push for interoperability via several directives, the deployment of ERTMS remains limited. Railway companies were used to operating in monopolistic markets and driving the evolution of railway systems at a national level, in cooperation with designated industries and full support from national authorities. They now have to prepare for a competitive environment in which supra-national directives dictate the evolution of the railway market.

Part II – Developing a pan-European railway standard in the era of liberalization

A number of studies (de Tilière, Emery et al., 2003; de Tilière and Hultén, 2003) have pointed out that a shift regarding innovation has taken place in railway systems during the early 1990s. Before that leading countries mainly had a national market with a national operator working with a main manufacturer for a defined scope of supply (i.e. market share between national manufacturers according to key technologies). National industrial policies were always in the background and the relation between operators, institutions and governments were very tight (see Dobbson 1994; Quinet 1999; de Tilière 2001)[25]. The change agents for the system architecture were the duo operator-manufacturer. The manufacturer proposed technological specifications according to the degree of innovative solutions required by the operator (at the system level). Except for international trains, there was neither real need nor demand for trans-border standardization. One could even argue that standardization was seen as a threat by suppliers – the potential economies of scale realized by the suppliers being offset by rents extracted from their captive clients.

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[23] At the same time, with investment cycles that are in many cases around 30 years, railway undertakings remain supplier-dependent.

[24] There is currently no mechanism for ERTMS migration built in the standard.

[25] Unsurprisingly, national industrial policies played a key role in the development of rail innovations.

The turn of the 1990s saw the end of this "national rail market" equilibrium. Supranational legislations started to impose new rules on domestic jurisdictions. For example, procurement rules imposed by the World Trade Organization now prevent the past practices of contract study allocations. Efforts at market liberalization at the European level also created a fundamentally new environment with different actors operating under different power relations – the most obvious example is the vertical separation of infrastructure management from train operations.

Some ERTMS standardization issues

While ERTMS was supposed to be a major step in fostering the creation of a single European railway market, the difficulties in standardization and the disappointing level of deployment questions what type of institutional setting could best enhance the changes for achieving a truly interoperable European railway market. In fact, the question of standardization has much larger implications. Some of the major stakeholders in the ERTMS ecosystem have recently voiced their interest into exporting the ERTMS abroad. The International Railway Union (UIC) and suppliers (grouped under UNIFE) are showing interest in fast-growing markets such as China or India. Adoption of ERTMS as a global standard, instead of a regional/European one, would put additional barriers to the temptation of national railways to customize their train management systems. However, it would most likely require re-thinking the current standardization and harmonization processes.

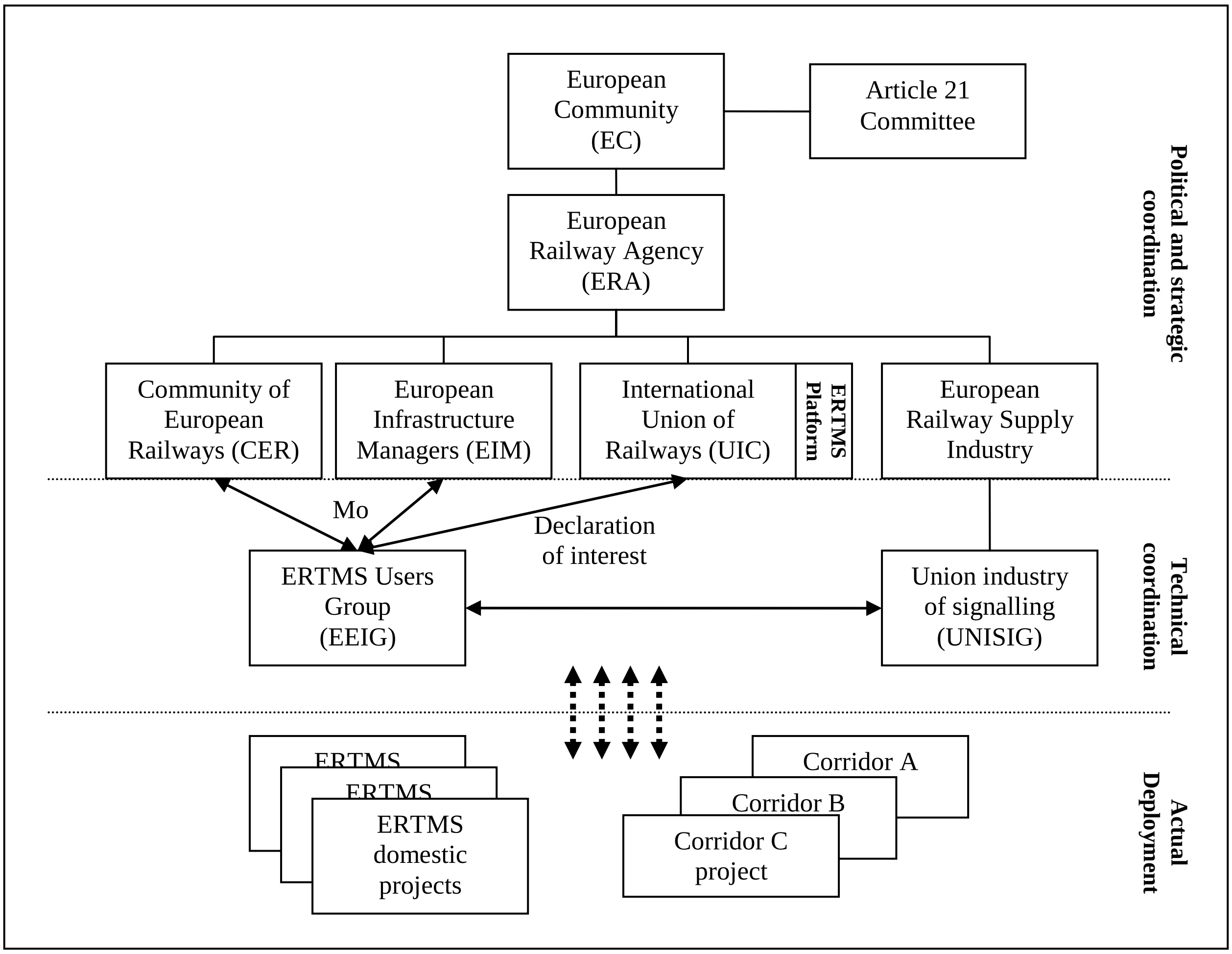
For a start, it is important to recognize that standardization of ERTMS takes place in a complex institutional setting making coordination an important issue (see Figure 2). A number of institutional measures were taken in this direction. In order to alleviate the coordination issues, the EC established the European Railway Agency (ERA)[26]. Attempts to improved coordination issues were made by the signing of Memorandum of Understanding (MoU) in March 2005 between the EC and the railway industry (i.e. UNIFE, infrastructure managers and railway undertakings) to promote the cohesive and coordinated deployment of ERTMS in general and ETCS in particular. The railway industry undertook to assist Member States in the preparation of national plans for the deployment of ERTMS and the Commission in its work of consolidating these national plans into a European plan. The Commission expects the railway industry to collaborate fully on preparing studies for working out, in particular, the costs of migration to ETCS in the main corridors of the trans-European network. A second MoU on the cooperation between ERA and the European Standards Organisations (CEN, CENELEC and ETSI) was signed in May 2007[27]. The Memorandum is aimed at establishing a cooperative relationship between the standardisation activities for the railway sector and legislative initiatives. It also aims at clarifying the relations between ERA and the ESOs regarding the political and technical framework for cooperation for European Standardization in the field of railways. Among others it will improve the specifications for interoperability. This agreement is part of a larger effort to ensure cost efficient and effective use of resources to better deliver European Standards and other European standardization products more efficiently in order to support market innovation, achieve both a coherent approach to standardization in new areas including converging technologies and a consistency

[26] EC Regulation n° 881/2004.

[27] Directive 98/34 recognizes three European Standardization Bodies: CEN, CENELEC and ETSI. TC256 is responsible for all railway mechanical standards, CENELEC TC9X for railway electrical standards and ETSI for telecommunication standards. Consensus-based working groups of technical experts and stakeholders are drafting European standards, called the "European Norms" (ENs). The main output of European standardization is the harmonization of technical specifications in the European Union.

in standards development[28]. These high-level agreements will help pave the way for a gradual establishment of an integrated European railway area.

Figure 2: ERTMS ETCS Ecosystem (without GSM-R)



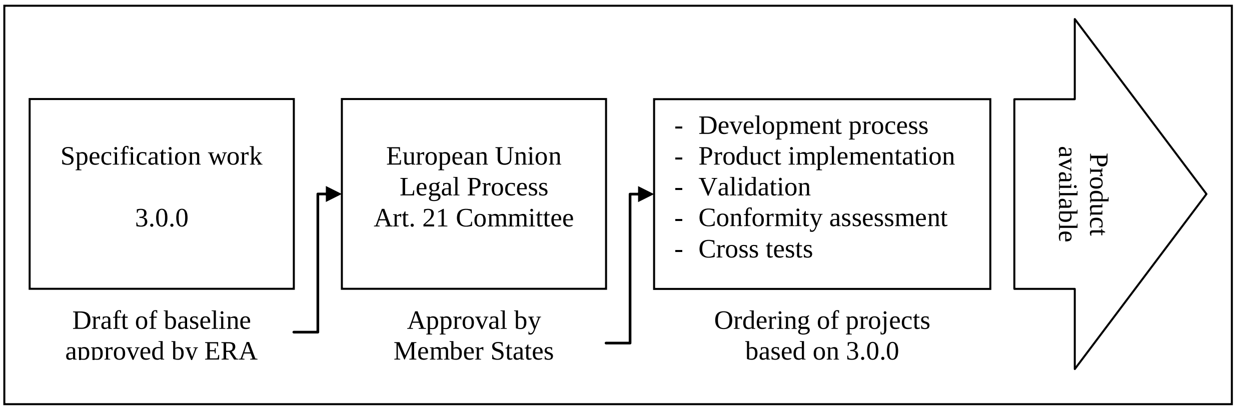
Source: Adapted from Querzè (2007) and personal interviews.
Note: The Article 21 committee is responsible for the development and application of the interoperability directives. ERA ensures the Change Control Management (CCM) of the ERTMS specifications. Established in 1999, the European Signaling Industry (UNISIG) is a technical body established by six companies for writing ERTMS/ETCS technical specifications. EIM, established in 2002, counts 12 infrastructure managers. It is a designated representative body within the ERA led ERTMS CCM process. EIM established an MoU with the ERTMS Users Group for technical support (CER has an identically worded MoU). EIM and CER jointly developed proposals for a methodology of evaluation of changes and for future funding (specifications, operational rules, testing and consolidation, site testing). The ERTMS Users Group is a European Economic Interest Group (EEIG) constituted by the Railway Administrations of France (RFF), Germany (DB), Italy (RFI), Spain (ADIF), The Netherlands (ProRail), United Kingdom (Network Rail) and Sweden (Banverket) plus SBB (Switzerland) as cooperating Partner. Under the aegis of the EC and of ERA, the member railways are working in co-operation with EIM, CER and UNISIG for the harmonization of the technical specifications and of the operational regulations of ERTMS. The role of National Safety Authorities role is defined in art 16.2 Directive 2004/49: a) authorizing the bringing into service of the structural subsystems constituting the trans-European Network […] and c) supervising that the interoperability constituents are in compliance with the essential requirements […].

[28] CEN and CENELEC agreed to establish a European Standardization System Group tasked with achieving more streamlined rules for the development of European Standards, with particular attention to the involvement of all stakeholders, and to create a high-level mechanism to solve the technical issues that arise from the standardization of emerging and converging technologies.

The issue of coordination questions who should be involved at all in the standardization process. For instance, hundreds of change requests have been made for the next STS release. Even if the common corridor approach should help alleviate the rising number of change requests, one can seriously question why organizations which haven't yet built an operational line are allowed to come up with change requests in the first place.

Coordination is also necessary at the TSI level. For example, the need for an amendment to the TSI came after a study, carried out by manufacturers in early 2007, revealed that certain ambiguities in the specifications had not been interpreted in exactly the same manner for certain projects already in operation as well as for projects about to be put into operation. These ambiguities meant that, in certain cases, trains equipped by different manufacturers could potentially behave differently in the same situation. ERA worked on the basis of 'Change Requests' (CRs) drawn up by the rail sector, in particular by the manufacturers. The consolidation of version 2.3.0 of the ERTMS specifications that will be brought about by the latest amendment is a crucial step needed before moving on to the planned version 3.0.0 of the system requirements: without this consolidation, it would not have been possible to guarantee that 'version 3' trains could run on 'version 2.3.0' lines[29].

Figure 3: Specification and development of 3.0.0 products



Source: Adapted from Gillan (2007)

Not surprisingly, coordination is also (even more) needed in the deployment phase of the technology since further standardization takes place in parallel. A number of elements emerged related to the standardization of ETCS emerged from the study of deployment in Switzerland (Laperrouza, 2008). First, ETCS is much more related to operational than to technical aspects. As a result, standardization (or harmonization) of operational rules will be as important as pure technical interoperability. While the publication of a European rulebook is an effort may be commended if won't probably be the solution to all the problems. For instance, experts drafting operational rules may not have the knowledge about the national differences – overlaying ETCS on existing systems (i.e. with level 1) can only have a national solution but never an interoperable solution with driver exchange. One often hears that ERA's work on operational rules and on SRS is too theoretical and has no relationship to applications. Second, in the words of a senior engineer, "you can only find all failures with a lot (thousands) of runs". The lessons from the Olten-Luzern pilot line have been instrumental in

[29] The ERTMS standard version SRS 2.2.2 was completed by an EC decision in April 2004. These SRS 2.2.2 specifications have been included in the directive 2002/731/CE related to the Technical Specification of Interoperability (TSI) for the European High Speed Network.

the successful deployment of the two commercial lines[30]. The test period allowed the operator to adjust its ERTMS migration strategy. Similarly, experiences gained from Corridor A will be very useful for the other corridors (as a common system). For example, a rulebook of applications for Corridor A could serve as a legal document at the EU level. Third, the further development of ETCS (and in particular SRS 3.0.0) is jeopardized by the losses incurred by equipment manufacturers for the deployment of the two lines. In the past, error correction happened via suppliers and finding a solution minimizing the impact on contract and timing of commercial opening of the line: this no longer possible – the solution to locally optimize with your supplier may not be the right one for the rest of the network even if the contracts are still managed by individual railways with individual suppliers – there is no economic reason to force them to change this way of behaving. For sure, the increase of commercial projects will diffuse know-how and reduce interoperability issues. Similarly, operational rules will slowly get harmonized through the running of international trains along corridors.

Another significant problem is the long time needed by the European Standardization Bodies to deliver a European standard. This can take longer than 5 years, and in some cases even up to 10 years. Some vital TSIs may take more than 20 years to implement. The TSI approval process often remains national in scope and outlook. Many TSIs, such as the HS & CR RST, still lack the new or amended standards to make EU-wide homologation possible and depend upon annexes in the interim. This can inhibit the mutual recognition of test results making multi-system approval slow and expensive. This development time is indeed far too long when compared to the development of the TSIs, which are both legally binding and technically detailed documents. The long development time of European standards has in the past reduced significantly the number of standards available to support the achievement of the TSIs. Hence in order to ensure that the TSIs can be implemented within reasonable timeframes, they now contain highly detailed specifications within annexes to the TSIs. This leads to the TSIs being larger and more technically detailed than originally foreseen.

Finally, standardization takes place in parallel to the railway market's liberalization which involved major re-definition of the stakeholders, including at the institutional level[31]. For instance under AEIF, responsibilities were clear: the railway sector was in charge of technical proposals while politics would give their formal approval. Nowadays, ERA has taking over the full responsibility. The railway sector acts only in a supportive function (represented in working groups). There are no sector representatives anymore in the Article 21 Committee. In the market, operators (RU/IM) are running shorts on resources and expertise for working in parallel for national standardization bodies, CEN/CENELEC/ETSI and TSI on top of keeping update of UIC leaflets[32]. At the same time, the supply industry cannot bear any more the high cost and time consuming procedures to respond to fragmented legislation and standardization.

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30 The trial included 59 units of rolling stock operating over a 32 km route. With 140 trains per day, the trial represented more than 60'000 train runs (about 2 million km).

31 The history of ERTMS revealed the importance of coordination between the numerous stakeholders already during the technical phase.

32 The UIC publishes leaflet – prepared and drafted within the expert groups of the UIC Forums and Platforms – about infrastructure, technology or operations. The leaflets are revised at the request of operators (RUs/IMs) resulting from the needs of operation and linked to other standards. They are kept updated as a knowledge base for the UIC members and for supporting the process of the elaboration of TSI and EN (CEN/CENELEC), ISO, COTIF, OSJD, etc. Leaflets 73 deal with signaling and interlocking (e.g. adaptation of safety installations to high speed requirements, ERTMS/ETCS).

The European Railway Agency (ERA)
Coming in the footsteps of the European Association for Railway Interoperability (AEIF), ERA was set up to help create an integrated railway area by reinforcing safety and interoperability[33]. Its main task is to develop economically viable common technical standards and approaches to safety, working closely with railway sector stakeholders, national authorities and other concerned parties, as well as with the European institutions.

The Commission has mandated ERA to perform certain activities under Directives 96/48/EC and 2001/16/EC. This includes: 1) preparing the review and updating of TSIs and making any recommendations to take account of developments in technology or social requirements (e.g. those who indicate the exact format of the messages which have to be exchanged between the track and the train); 2) contributing to the development and implementation of rail interoperability – ensure that the TSIs are adapted to technical progress and market trends and to the social requirements; 3) monitoring progress with the interoperability of the railway systems; 4) examining from the point of view of interoperability, any railway infrastructure project. It is expected that these measures will gradually create an open market for rail products and systems, create true operational rail interoperability at a European level, and reduce the high costs and burdens currently being experienced from the perpetuation of specific national technical solutions and systems.

In practice, the Agency also acts as the system authority for ERTMS[34]. The two main axes of ERA as system authority are: 1) configuration and quality control which includes repository of all specs, quality review, cross check, consistency and gap identification and 2) system evolution and change management which includes baseline planning, system version management and backward compatibility. The EC will also be able to ask the agency for assistance in the evaluation, as far as interoperability is concerned, of projects eligible for Community financial support. As such, ERA plays a central role in the current and future technical development of ERTMS.

Discussion
The fact that ERA is considered as the system authority does not reduce conflicts of interests within the ERTMS ecosystem. In the case of the standard's evolution process, which is under ERA's responsibility, there has been an attempt by ERA (led by the ERTMS unit manager) to take the lead in the next standard release via the creation of a working group. The attempt failed due to a general blockage of the stakeholders. The appointment of a European coordinator to facilitate the coordinated deployment of ERTMS in general and of the ETCS signaling system in particular is an attempt to bridge the gap between ERA's technical and political work, and the actual deployment. The coordinator's role consists facilitating the preparation of coherent and economically viable national deployment plans (through corridors) and pinpointing any problems in the implementation of these plans (European Commission, 2005). In a sense, it proves the current inability of the institutional setting to have ERA act as the sole agency in charge of ERTMS. Moreover, coordinator's mandate is more geared towards short-term success (deployment via corridors) than towards long term sustainability (standards). In practice, ERA finds itself in a situation where it plays both a technical and as political role, which places additional pressure on the agency both from the EC and the ERTMS coordinator (Karel Vinck).

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[33] In September 2006, the European Association for Railway Interoperability (AEIF) officially transferred all its documentation to the European Railway Agency. AEIF was the joint representative body mandated by the EU Commission to lay down the Technical Specifications for Interoperability (TSIs).

[34] ERA is also in charge of establishing transparent processes to manage the ERTMS system changes.

While the technical competence of ERA is not in question, this cannot be said of the current institutional arrangement which leaves ERA devoid of real powers. ERA does not have any regulatory powers. It only submits opinions and recommendations to the European Commission[35]. In other words, it has no decision power. Second, the gap between technical coordination and actual deployment is hardly filled by ERA. The "reality of corridors" never reaches ERA. In order to minimize transaction costs, ERA doesn't work with individual suppliers but representative organizations, e.g. UNIFE, UNISIG. There are too many filters between the reality (projects) and ERA, namely the various organizations (EIM, CER, UNIFE, etc.). Moreover, all stakeholders may not be on the same footing. Member States are historically so close to infrastructure managers that suppliers and train operators might be disadvantaged. Third, the standardization process itself poses a problem – going back and forth between ERA and Member States. For time being ERA doesn't have a "carte blanche" to modify specific texts[36]. However there a possibility to say "we Member States trust that you do the right thing" and by 2008 TSI can make specific reference to documents which are published by the agency itself, a way to skip this complete approval. ERA is also working with representatives (suppliers) to write down a legislation imposing them what to develop, a sign that the agency is establishing its power. Last, investment decisions are still made at the local and national level which distorts incentives. One therefore ends up with very good interoperability inside one country.

ERA's task is made difficult by the fact that most railway undertakings are just contemplating moving away from their existing signaling systems – very often ETCS is overlaid over an existing system as a migration tool rather than replacing an existing signaling system. This obviously has consequences on the motivation of the stakeholders to take part in the standardization process. ERA is also partly struggling because it has the mandate to maintain the specifications in a state that is proper for delivering interoperability but nobody is satisfied with the proposed solutions. It is easy with technical details to try to really find your own solution without reflecting on what would really we the impact in the longer term and on the wider acceptance of the system.

In summary, the ERTMS standardization process requires power, of which ERA is currently devoid since it is "technically" only allowed to make recommendations. In addition, the newly created agency has to operate in a landscape previously ruled by countries. More broadly, one central question is whether the current standardization process for ERTMS best serves the objective of interoperability. The EC wants technical and operational interoperability. In practice, this can only be guaranteed by ETCS level 2 and 3. Too frequent changes of "soft" versions must be avoided, which moreover pushes for expensive "hardware" modifications most of the time (cf. example of PCs and « Windows syndrome »). The current problems may be due to the relative youth of the agency itself as well as to the large scope of the ERTMS project. ERA is struggling with the first instances of dealing with a European railway system that must be considered as one entity.

Coen and Thatcher (2007) argue that the EC and national regulators maintain controls over European regulatory networks (ERNs). The study of ERTMS leads to a similar conclusion: while ERA is not a regulatory agency *per se*, it plays, together with the other railway stakeholders (industry associations and their members), a strong regulatory role but only to a

[35] It may also send technical opinions to the European Commission or Member States' Committees.

[36] For some ERA is "manipulated" by the EC and lacks autonomy.

certain point. It therefore finds itself in a weak position with a limited set of powers and strong oversight.

A number of questions remain open. First, what explains that, unlike most other European network utilities (like telecommunication or electricity and gas), the railway sector does not have a European Regulators Group? Second, is ERA a hybrid solution between a sectoral agency and a European regulator towards which the EC wants to go in order to restrict the delegation of power (formal decision powers are with Art. 21 Committee)? Third, does the current institutional framework – and the creation of ERA – offer the optimal design to the technological and competitive shifts taking place in the railway sector?

Conclusion

In the past, national railway systems were much more isolated. Technologies and institutions pertaining to the sector tended to be naturally integrated. Governments usually owned and ran a single railway company which in turn was linked with a preferred supplier. There was a tendency to solve technical issues without consulting other stakeholders. As a result, each European country went about developing its own national railway system architecture resulting in fairly strong technical system boundaries. This led to a high degree of interoperability of railroad traffic at the national level but very dissimilar railway philosophies between countries. The resulting lack interoperability can be seen in technical aspects (e.g. gauges, energy systems) as well as in operational rules. At the beginning of the 1990s the EU opted for the creation of a competitive railway sector. To do so it has passed numerous directives aimed at liberalizing the railway market (e.g. through the unbundling of railway activities). Keeping with the principle of subsidiarity European countries have adopted a variety of paths to approach the mandated de-regulation.

One central characteristic of networked systems is the need for technical interdependence or compatibility. As a result, making the European railway sector more competitive can not rely solely on an economic approach. Measures need to be taken to guarantee an interoperable railway system across Europe. A cornerstone in establishing such a European-wide technically interoperable railway system lies in the signalling system. The EU together with a number of stakeholders has spent the last 20 years in developing a pan-European control and command system (ERTMS) which should allow a train to drive from Sweden to Sicily without changing the train set. This implies solving the technical interoperability challenge and finding a way to harmonize the different railway philosophies.

On one hand, standardization and harmonization initiatives are necessary given the political and economic objectives of liberalized markets. On the other hand, market liberalization warrants the unbundling of market players which makes standardization and harmonization efforts much harder. The difficulties faced by the new created European railway agency (ERA) in standardizing ERTMS highlight well the need to align technology and institutions. The task is made even harder since it is taking place in an environment moving from cooperative agreements to competition in international traffic. At the same time, the bottom-up approach to deal with technology harmonization (from national rules to international rules to international agreements) has been reversed (from TSI to European standards to national rules). It also serves as a reminder that, as in other utilities, sequencing of liberalization matters. While the liberalization of the European railway market was aimed at increasing its competitiveness, making train and track work together on a given project in practice seems to be harder now than before infrastructure management and train operations were unbundled. In the case of ERTMS one could go as far as arguing that the EU went the wrong way by pushing for unbundling before achieving technical harmonization.

In addition to the question of sequencing, the study of the deployment of ERTMS in Switzerland (Laperrouza, 2008) has highlighted the importance of proximity and close cooperation between actual projects and all the stakeholders involved. Only an integrated ecosystem of actors can ensure the successful deployment of ERTMS. As the current deployment levels of ERTMS shows in the rest of Europe, the mere existence of ERA, the availability of safety rules and the interoperability directives are necessary, but not sufficient, conditions for seamless cross-border rail services in the Internal Market. By the same token, interoperability should not be reduced to the much more simplified concept of technical compatibility. The question of further harmonizing operational rules and philosophies on a European level remains at the center of the creation of a single rail market (Di Pietrantonio and Pelkmans, 2004). Standardization goes further than simply resolving technical issues. The real challenge for the European railway sector will be to make sure that the emergent institutional framework remains coherent with the technologies it aims to develop and deploy. At the end of the day, the most relevant measure of "full interoperability" and therefore of system performance will be the number of trains equipped with a single control and command signalling system that cross borders.

Appendix 1: Deployment of ERTMS Level 2

Table 3: Summary of ERTMS Level 2 in operation (trackside projects)

	Commercial operations	Length	RBC	SRS	Trains in operations	Type	Comments
BE L4 HSL	March 2008	35 km	2	2.3.0	n.a.	HSL	Alstom; 300 km/h
CH Lötschberg	December 2007	35 km	1	2.2.2	108/day	M	Thales; 4 interlockings
CH Mattstetten-Rothrist	July 2006	45 km	1	2.2.2	270/day	M	Alstom; 250'000 km /month with an average delay below 30s per week per train; 2 min headway; 15 types of trains
DE Berlin-Halle/Leipzig	December 2005	145 km	4	2.2.2	n.a.	?	Thales; 200 km/h
IT Rome-Naples	December 2005	216 km		2.2.2	12/day	HSL	Alstom-Ansaldo; 300 km/h, 30 trains equipped; 5 min headway
IT Torino-Novara	February 2006	84 km		2.2.2	12/day	HSL	Alstom-Ansaldo, 300 km/h, 30 trains equipped; 5 min headway
NL Betuwe	June 2007	107 km	3	2.3.0	0/day	F	Alstom; 4 types of locomotives
NL HSL-Zuid	March 2008	45 km	2	2.3.0	0/day	HSL	Siemens-Thales; 300 km/h

Source: Adapted from de Tilière (2007) and International Technical Committee (2008)

Table 4: Summary of ERTMS Level 2 under test (trackside projects)

	Test start	Length	SRS	Type	Comments
BE L3 HSL	n.a.	n.a.	2.3.0	HSL	Alstom; Bomardier
ES La Sagra-Toldeo	November 2006	21 km; 1 RBC	2.2.0	HSL	Thales
ES Lerida-Barcelona	June 2007	176 km; 4 RBC	2.2.0	HSL	Thales
ES Madrid-Lerida	May 2007	470 km; 5 RBC	2.2.0	HSL	Ansaldo; commercial service in September 2007; 320 km/h
ES Madrid-Valladolid	2007	184 km; 3 RBC	2.2.0	HSL	Thales
ES Cordoba-Malaga	2007	155 km; 4 RBC	2.2.0	HSL	Invensys
FR Vaires-Baudrecourt	June 2007	300 km	2.3.0	HSL	Ansaldo; commercial service without ERTMS
IT Milano-Bologna	n.a.	182 km	2.3.0	HSL	Ansaldo
IT Milano-Novara	n.a.	40 km	2.3.0	HSL	n.a.
NL Amsterdam-Utrecht	n.a.	30 km; 2 RBC	n.a.	Mixed	n.a.

Source: Adapted from de Tilière (2007) and Kema-RTC DHV B.V., RINA et al. (2007)

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