Chapter 1
Introduction

Simon Collart-Dutilleul

1.1 Introduction

Before detailing various aspects of the global growing phenomenon relative to railway high-speed lines, let us present it in few words. The global length of high-speed lines is increasing fast, in Europe and outside Europe (see Fig. 1.1). The commercial speed is gradually increasing as well (Fig. 1.2). Considering both these aspects leads to investigate seriously new railway services. Actually, going faster means going further using the same quantity of time. This quantity of time has a social meaning. As an example, it can be the travel time that people are able to use daily to go to their work. It can be the travel duration accepted for holidays, etc.

Providing high-speed railway services to a large amount of people should naturally lead to innovative uses from a societal point of view. For this reason, the first chapter of this book is an economical point of view on these international passenger lines.

Nevertheless, when we arrive to a frontier, the national laws are changing. This book aims to answer whether this legislative gap between two neighboring countries is an unbreakable wall or not. As the first answer of a legislative problem is a legislative answer, the second chapter of this book presents a European initiative normalizing on-board systems of trains through Europe and sharply defining their communications with the track-side part of the system. This is the ERTMS (European Railway Traffic Management System) specification.

Is ERTMS a solution that may be applied only in Europe? The first answer comes from the use of ERTMS in Australian high-speed lines (Katie 2016), for example. Another argument is the industrial use of CTCS in China, which is shortly presented

S. Collart-Dutilleul (✉)
COSYS/ESTAS, Université Gustave Eiffel, Villeneuve d'Ascq, France
e-mail: simon.collart-dutilleul@univ-eiffel.fr

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in the third chapter of this book. The reader may consider whether this technical specification is far from the ERTMS one.

The fourth chapter of this book is devoted to a state of the art of modeling effort in the railway area. It closes the first part of this book devoted to an economical and technological context documentation.

The second part of this book provides a particular point of view leading to a methodological solution proposal.

Before going deeper, the basic data related to the above presentation are presented.

1.2 Fast Growing of High-Speed Lines Leading to New Paradigms

High-speed train development is increasingly growing, when you consider the number of lines or the number of trains. Let us consider the breakdown of the length of high speed lines in march 2011 (the exploitation speed is bigger than 250 km/h) in all the world (UIC source, 2011)

- 15,231 km of exploited lines,
- 9172 km of being built lines,
- 17,594 km of project of line.

It is easy to see that the total length of the projects of lines represents 15% more than the already exploited lines. Moreover, concerning the total length of work in progress of new lines building, it is a little bit less than 60% of the exploited lines. It is not surprising to see that the prospective evolution of high speed lines is a rapid increase (see Fig. 1.1). Focusing on Europe, the length of railway's high-speed lines is expected to double in less than 15 years.

All the data show that the high-speed train is entering a new dimension. All these new lines will need some operating and safety rules. The current safety expertise pertains to smaller sized systems. Anyway, a lot of new lines mean new particular case studies ensuing from new particular infrastructures and new contexts: as an example in Fig. 1.1 until 2000 years, there are some high-speed lines in other places than Europe and Asia (see the green curve in Fig. 1.1).

The last aspect to be integrated is the speed evolution (see Fig. 1.2). Increasing more than 15% starting from the maximal high speed in 2000 means that you can go further using the same time. Focusing on the French country further means mainly somewhere outside of France. Another state means another legislative context, another safety culture, etc. In other words, high speed makes possible new kinds of services, bringing new kind of problems.

Considering the line Paris-Marseille that corresponds to a real need and is well functioning, it is possible to imagine the possibility of reaching other European towns, even assuming that the commercial speed does not increase.

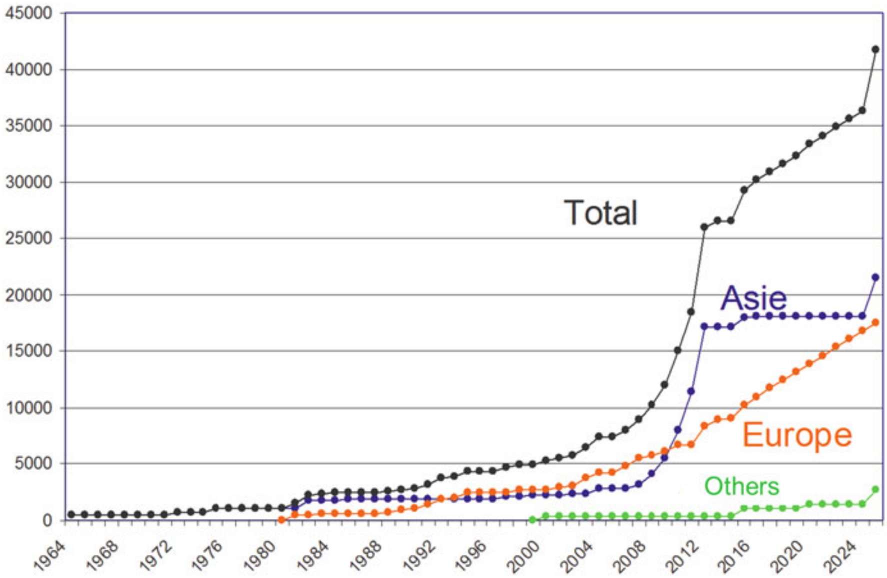

Fig. 1.1 Prospective evolution of high-speed line kilometers in the world (UIC source, 2011) (Color figure online)

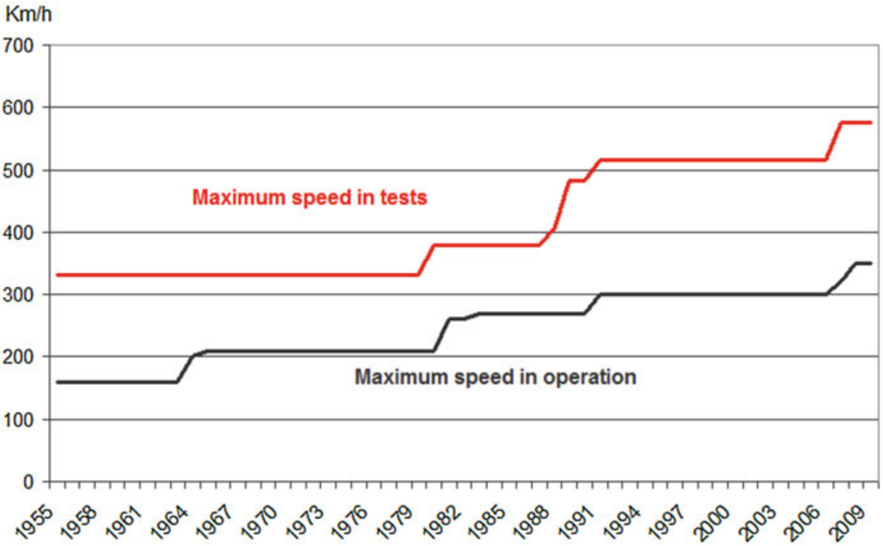

Fig. 1.2 Maximal speed evolution (UIC source, 2011)

Paris is actually the capital of France, but it is probably not true for every point of view. Making the strong assumption that crossing a national frontier costs nothing,

Fig. 1.3 A prospective vision centered on the Town of Paris (Color figure online)

the red circle in Fig. 1.3 may be moved to the right, to the north, or to the south, connecting more European economical capitals altogether.

Moving this red circle is useful to build a vision of what may be achieved in the following years, taking into account the run of the technology and assuming that the legislative wall does not exist.

The next section focuses on legislative aspects.

1.3 National Specific Rules: Framework Characterization

Trans-national high-speed lines have to tackle with the interoperability task. ERTMS/ETCS is the European proposed solution for on-board systems, whereas this technological and legislative context has to be integrated in all the different European countries. New operating rules have to respect both European interoperability directives and national safety rules (Fig. 1.4).

Aligning national safety rules may seem to be an easy solution. It is true considering that a rule is only a piece of paper, but when you integrate the fact that a rule is a list of actions of technical disposition relative to a given context, to be executed in order to achieve the needed level of safety, it becomes less simple (Fig. 1.5).

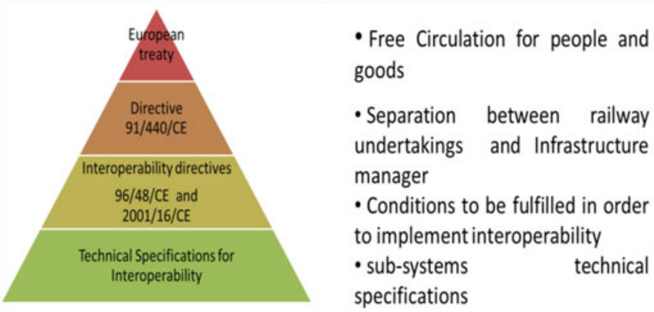

Fig. 1.4 ERTMS legislative context

Fig. 1.5 Operating rules positioning in a legislative hierarchy

The following section provides the basics of safety rules engineering.

1.3.1 Safety Rules

1.3.1.1 Definition

A safety rule is a set of coordinated actions to be made in order to make the set of all operations reach an acceptable level of safety. It includes

1. an application context (location, date, type of operation),
2. some conditions (constraint to be fulfilled for a valid application of the rule, as an example, a train arrival has to be signaled before a given distance from the concerned zone), and
3. a list of action to be made (as an example, moving the team to a non-dangerous zone).

Two kinds of safety rules may be identified:

- The first one imposes some actions preventing from an accident occurrence: this is the barrier concept.
- The second one demands an organization that decreases the occurrence probability of an accident or attenuates its severity.

A superficial analysis could directly demand first-type rules rather than second one. Anyway, the real pragmatic question, tacking the context into account, is What can be done?

Actually, a combination of the two types of rules may be used to reach the acceptable safety level. The question of which kind of rule should be applied becomes critical when a higher level rule requires a barrier kind of rule. In this case, applying a rule that rather decreases the severity does not correspond to the specification. Locally, the level of safety may be correct but form a global system safety point of view, some dangerous occurrence chains may be still allowed.

1.3.1.2 Bureaucratic Rule-Writing Approach in a Dynamic World

One of the more interesting contributions concerning safety rules in railway is Hale en 2003: *"Management of safety rules: the use of railways" Hale et al. (2003).*

Nevertheless, this document claims that there is only a little quantity of scientific articles which deals with this subject.

A classical analysis considers that a given rule uses a collective knowledge to define some safe behaviors and some safe equipment. This knowledge is used to make them run safely (Baumard 1999).

Bureaucratic Approach and Safety

The assumption is that the rule editor has a general knowledge of all the possible contexts and overall knowledge of the global system. This top-down approach puts a high level of competency on the high-level layer of management (Hovden 1998). One of the goals is to make the behavior deterministic at the lowest level of the system.

Under this strong assumption, the rule can be edited using a simple process, because the editor must have a total knowledge. Using several-leveled rule decomposition is not mandatory, because the principle to be implemented is known by the editor.

The high responsibility-leveled editor writes the rules and defines the way it is applied. In this case, there are no real consistency problems. The lower levels only receive a delegation for controlling the rule application.

All these assumptions are difficult to meet in a dynamic world, as an example when there are some new technological environments and some new services.

Collective Knowledge?

When the knowledge is collective, it is useful to obtain all the needed information by the one who has a part of this knowledge in order to build a safety rule.

Using a purely knowledge approach, the knowledge increases in case of accident, because the scenario is added to the common knowledge.

In a fast-changing world, it is not possible, because we may build knowledge corresponding to a system that does not exist anymore. The preliminary risks analysis is a methodology to be considered (Rasmussen and Svedung 2000).

Anyway, there is a need for a predictive approach (Kirwan et al. 2002).

1.3.1.3 French Point of View

According to the directives from SNCF (IN3600), the text of a rule is both a product and a project.

A rule is a product because it has to be delivered to some clients who need it. By the consequence, the client satisfaction of these clients is an important parameter.

When the creator of a rule is not the client, one may think that the client understanding of the rule is the best because he/she is the one who applies the rule in a real context. Nevertheless, this assertion cannot be accepted for several reasons.

Accepting a misunderstanding as a solution is dangerous because it is building a gap between the the knowledge of the designers and that of the operators.

When they are several kinds of users for a given rule, their application context and technological culture may be different. In this case, the only way to build a safe collaboration is to make them apply the same rule (i.e. applying the same actions in the same situation).

Anyway, if there are several understandings of a text, who is right?

In order to propose a solution, the state of the art was consulted:

> The rule editor is the leader of its translation (Reason 1997).

By translation, one may understand, instantiating of principles included in a rule in some particular contexts.

As misunderstanding is not allowed, one man must be able to give a unique signification to the text. If this condition is respected, behavior becomes to be deterministic.

Moreover, the editor of a given rule is a client for higher level rules, which must be respected. As a consequence, when he/she orders an action in order to fulfill another rule, the interpretation of the current rule has to preserve the compatibility with a set of rules: this is typically the role of the rule editor.

Actually, when a rule does not respect the higher rule, it is just outlaw: the highest safety rule comes directly from the government of the concerned state.

1.4 National Rules and Interoperability: A Problem to be Solved

Writing safety rules is not an easy task, but many efficient safety rules have been written.

Standing a problem of rule alignment for several countries looks non-tractable. Anyway, half of the problem is solved by the use of an ERTMS like technological context.

The first part of this book presents ERTMS as a contribution to achieve interoperability, while the the second part of this book details a proposal based on ERTMS taking into account the national-specific contexts. It proposes to use model engineering as an abstraction layer aiming at aligning various needed knowledge. The main idea is to propose local alignments by the use of common functioning modes for border crossing.

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