COMPENDIUM on ERTMS

European **R**ail **T**raffic **M**anagement **S**ystem

edited by UIC
under the coordination of **Peter Winter**

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European Rail Traffic Management System

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Preface by the Chairman of the UIC ERTMS Platform

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There is no longer any doubt as to the key role of ERTMS for the revitalisation of the European railways, and it is generally recognised that the point of no return on this road has been passed.

The International Union of Railways is extremely pleased to distribute this ERTMS compendium on the occasion of the ERTMS World Conference 2009 in Málaga, Spain, one of the EU Member State where ERTMS has most thoroughly and successfully been implemented, mainly on new high-speed lines.

The UIC ERTMS Platform, which I have the honour to chair, was established in 2006 to share experience on ERTMS implementation and determine strategies for a feasible migration. Its key task is to contribute to the promotion of a viable migration strategy for ERTMS which is compliant with the rail sector’s interests as a whole.

In this book, a team of authors actively involved in the ERTMS development process for many years provides an introduction to and overview of the current status achieved, including the consolidation to be brought about by the new formally approved baselines for the ETCS and GSM-R specifications.

I hope that this book will help improve understanding of the complex ERTMS concept and facilitate its further implementation, thus rendering the railways more attractive and competitive.

Thank you, Peter.

Chairman of the UIC ERTMS Platform

Málaga, 31 March 2009

Michele Elia

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Chairman of the UIC ERTMS Platform
Michele Elia

Málaga, 31 March 2009

Preface by the main author

During the last 20 years, the second half of my career as a professional engineer in the rail sector, I have had the privilege of being actively involved in the development of ERTMS, an initiative jointly driven by the railways and manufacturers under the auspices of the European Commission. This broad Europeanising process will bring about profound reform of the rail system. The key driving factors are interoperability in the context of open-access infrastructure; safety and performance in rail operations; an open and competitive multi-vendor market for procurements; and cost efficiency over the system life-cycle as a whole. After a long history of national traditions in rail traffic management, a new harmonised European concept is becoming a reality, combining innovative approaches in technology, processes and the rules and regulations underpinning these.

In the course of ERTMS development, many difficult and conflicting issues have had to be faced by the numerous parties involved in the harmonisation of a multitude of completely different and incompatible points. Some of these controversial aspects are:

- National traditions versus European unification
- Integrated versus separated management of rail infrastructure and train operations
- Focus on high-speed versus universal application to all kinds of train services
- Users' interests versus suppliers' interests
- Infrastructure managers' interests versus operators' interests
- Signalling industry's interests versus GSM-R industry's interests
- Rolling stock suppliers' interests versus signalling suppliers' interests
- Short lifecycles in modern telematics versus long lifecycles in railway technology
- Technology versus rules and regulations
- Line side signalling versus cab-signalling
- Line side-based positioning versus train-based positioning
- Maximum safety integrity level across the board versus differentiated safety on existing lines achieving at least the same level as ensured by legacy systems
- Short-term benefit versus long-term benefit.

It has taken a long time to reach a common understanding on the scope of traffic management in the rail system, since traffic management goes far beyond traffic planning and dispatching, including as it does signalling, control-command and train communications, all of which have strongly rail-specific and highly safety-critical features.

This compendium is intended to introduce the reader to the complex ERTMS concept by giving an overview of all the relevant sub-projects. I hope it will help facilitate the work of all parties and players involved in the further generalised roll-out of ERTMS and thus benefit a safe, high-performance and sustainable rail transport system.

I would like to thank warmly all those who have contributed to the production of this book, especially the co-authors and the numerous proof-readers.

Berne, 31 March 2009

Honorary Professor, Doctor in Engineering
Peter Winter

1 Introduction

Peter Winter

1.1 Traditional methods and means for rail traffic management

The functional structure of the rail traffic management system is outlined in a very simplified and generalised way in the figure 1.1 on the right.

Several layers can be distinguished. In this hierarchy, the top layer deals with the strategic dispatching of trains and traffic planning for the whole geographical area of the system. Methods and means used are similar to those applied for other means of transport and do not affect directly the safety of train operation or the interoperability. At the next lower level, the signalling comprises the far more rail specific and safety relevant devices for remote control, the interlockings and the outdoor equipment along the track. The bottom level consists of the trains which are linked to the fixed installations by means of train control-command devices. By nature, the latter are strongly relevant for the interoperability between trains and the infrastructure. As in every other production system, there is a need for communication by voice and increasingly data based within and between each of the layers. This is achieved by fixed networks and – especially between infrastructure and trains – by wireless radio communication which is also relevant for interoperability.

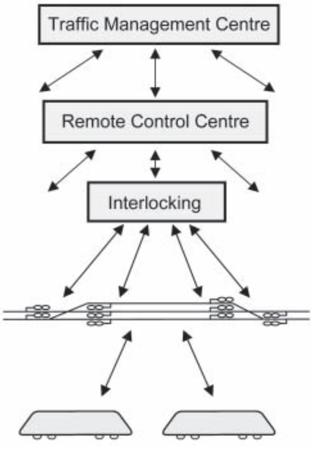

Figure 1.1: Functional structure of the rail traffic management system

1.1.1 Train dispatching and traffic planning

Originally, train operation was monitored at station level. In the 1950s dispatching centres were installed for the most important lines, where the movement of the trains was reported by telephone from the various stations and registered manually on paper by traffic controllers (see figure 1.2).

Figure 1.2: Traditional working place of a traffic controller

Since the 1980's, IT tools have been introduced to support the functions of timetabling, route planning and tracing of the trains in normal and degraded situations. The huge progress in general IT has allowed these processes to be automated to a large extent [1.a]. Paperless work with flat screen man-machine interfaces has become a state of the art standard as in many other sectors. Until now, these systems have basically been procured and operated at the national level. International cooperation is facilitated by the fact that many parameters relevant for timetabling, e.g. train numbering, have been harmonised by means of UIC codes.

1.1.2 Railway signalling

For safe and fast train running on lines and in stations, various methods and signalling technologies have been introduced over the years, using different kinds of signals for transmitting the information about movement authority and/or allowed maximum speed to the driver [1.b, 1.c]. These means have been developed basically at the national level with different types of signals and underlying philosophies. The range goes from semaphore, colour light code to speed indication by means of digital number (figure 1.3). Today it seems practically impossible to harmonise this panoply of devices and underlying rules and regulations.

Figure 1.3: Examples of lineside signals

Originally the signals (or flags) were activated locally. Later, interlockings were introduced for the control of signals within a certain area. Different designs have been developed in mechanical, electro-mechanical, relay or computer technology. In many European railways, there exists still a great variety of such devices which are highly relevant for safe operation of trains (figure 1.4).

Figure 1.4: Examples of non computerised interlockings in different technologies

For one or two decades, the design, engineering and operation of interlockings has been covered by general European CENELEC norms. However, de facto no European standardisation and unification has been achieved.

Track vacancy proving is another vital signalling functionality. Originally this had been achieved by station agents observing "physically" every train as it passed through the station. Later, different types of on-track technical device were introduced to automate this function: treadles, track-circuits and/or axle counters. These technologies, with elements on the track-side, have been fundamental to the development of railway signalling philosophy based on fixed block sections. For the block control between stations a step by step evolution took place from manual operation towards fully automatic control. Since the 1950's, relay based and later computerised devices have been introduced for the remote control of complete interlockings. Here too, there has been until now a lack of European harmonised operational and technical standards.

Treadle Track circuit Axle counter

Figure 1.5: Examples of outdoor equipment for track vacancy proving

1.1.3 Train control-command

1.1.3.1 General characteristics and extent

Not surprisingly, the efforts for European standardisation originated in the field of control-command systems which are highly relevant for the interoperability between trains and infrastructure. These systems are necessary for supporting the driver in the observation of lineside signals or replacing the latter completely by in cab signalling. The following table1.6 illustrates that currently about 20 different and non interoperable systems are in use. Some of them are very

Country	CC-System (status 2003)	Functionality	Technology used for data transmission
Austria	PZB/Indusi	discrete speed supervision	intermittent/inductive coil
	LZB	cab signalling	continuous/cable loop
Belgium	Crocodile	warning	intermittent/galvanic contact
	TBL1	stop	intermittent/inductive coil
	TBL2	cab signalling	intermittent/inductive coil
	TVM	cab signalling	continuous/track-circuit
Bulgaria	Ebicab	continuous speed supervision	intermittent/transponder
Czech Republic	LS	discrete speed supervision	semicontinuous/track-circuit

Table 1.6: Characteristics of the various European legacy control-command systems

Country	CC-System (status 2003)	Functionality	Technology used for data transmission
Denmark	ZUB 123	cab signalling	intermittent/transponder and optional semicontinuous/cable-loop
	HKT	cab signalling	semicontinuous/cable-loop
France	Crocodile	warning	intermittent/galvanic contact
	KVB	continuous speed supervision	intermittent/transponder
	TVM	cab signalling	continuous/trackcircuit
Germany	PZB/Indusi	discrete speed supervision	intermittent/inductive coil
	ZUB 122/262	tilt and speed supervision	intermittent/transponder
	LZB	cab signalling	continuous/cable-loop
Great Britain	AWS/TPWS	discrete speed supervision	intermittent/inductive coil
	TVM	cab signalling	continuous/track-circuit
	TBL	cab signalling	intermittent/transponder
	Selcab	cab signalling	semicontinuous/cable-loop
	TASS	tilt and speed supervision	intermittent/transponder
Hungary	EVM	discrete speed supervision	semicontinuous/track-circuit
Italy	BACC	discrete speed supervision	semicontinuous/track-circuit
	SCMT	continuous speed supervision	intermittent/Eurobalise
	SSC	discrete speed supervision	intermittnet/transponder (microwave)
Luxembourg	Memor II+	warning/stop	intermittent/galvanic contact
Netherlands	ATB EG	discrete speed supervision	semicontinuous/track-circuit
	ATB EG+NG	continuous speed supervision	intermittent/transponder
Poland	SHP	warning	intermittent/galvanic coil
Romania	Indusi	discrete speed supervision	intermittent/galvanic coil
Serbia	Indusi	discrete speed supervision	intermittent/inductive coil
Slovakia	LS	discrete speed supervision	semicontinuous/track-circuit
Slovenia	Indusi	discrete speed supervision	discontinuous/inductive coil
Spain	ASFA	discrete speed supervision	discontinous/inductive coil
	Ebicab	continuous speed supervision	discontinuous/transponder
	LZB	cab signalling	continuous/cable-loop
Sweden	Ebicab	continuous speed supervision	discontinuous/transponder
	Radioblock	continuous speed supervision	continuous/analogue radio and discontinuous/transponder
Switzerland	Signum	warning/stop	discontinuous/inductive coil
	ZUB 121	continuous speed supervision	discontinuous/transponder and optional semicontinuous/cable-loop

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old and simple. However, even in course of the last 30 years, at least three completely different systems for cab signalling in the context of high-speed train operation have been introduced. It is also remarkable that in certain countries several systems of different age, functionality and technology are in use. The table does not show to what extent two or more national systems are overlaid either on track-side or on the traction units.

There are big differences regarding the extent of the different types of legacy systems. Most widely installed are the PZB/Indusi, Crocodile and AWS/TPWS systems which are all in old

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