



COMPENDIUM on ERTMS

European Rail Traffic Management System

edited by 
under the coordination of Peter Winter

Eurail
press



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Contents

	Preface by the Chairman of the UIC ERTMS Platform	9
	Preface by the main author	11
1	Introduction.....	13
1.1	Traditional methods and means for rail traffic management.....	13
1.1.1	Train dispatching and traffic planning	13
1.1.2	Railway signalling.....	14
1.1.3	Train control-command	15
1.1.4	Railway communication	22
1.2	Driving factors for change.....	23
1.2.1	Open procurement under competition	23
1.2.2	Interoperability	23
1.2.3	Safety and quality of conventional and high-speed train service	26
1.2.4	Increase of transport capacity	27
1.2.5	Reduction of life-cycle costs	27
1.3	Precursor of ERTMS, similar developments outside Europe	27
1.3.1	French ASTREE project	27
1.3.2	German FFB project	28
1.3.3	Swedish Radio-Block system.....	28
1.3.4	Communication Based Train Control (CBTC) systems in North America.....	29
1.3.5	Advanced Train Administration and Communications system (ATACS) in Japan	29
2	Background for ERTMS	31
2.1	Importance of a future oriented rail traffic management.....	31
2.1.1	The emergence of a European railway policy	31
2.1.2	European projects in the field of rail traffic management.....	32
2.2	Legal and normative base.....	33
2.2.1	EU Directive for the interoperability of Trans-European rail systems	34
2.2.2	Technical Specification for Interoperability related to Control-Command and Signalling	38
2.2.3	Mandatory CENELEC and ETSI norms	45

- 2.3** **Involved parties at European level**46
 - 2.3.1 European Commission, ERTMS Coordinator, European Rail Agency ERA46
 - 2.3.2 Railway organisations48
 - 2.3.3 Signalling industry49
 - 2.3.4 GSM-R industry50
 - 2.3.5 Notified bodies.....50

- 3** **Traffic management layer: the Europtirails project**51
 - 3.1** **Europtirails project history**51

 - 3.2** **Europtirails functions**.....52
 - 3.2.1 Graphical real time information about international trains.....52
 - 3.2.2 Reporting about international train run57
 - 3.2.3 Data exchange on international train run57

 - 3.3** **Europtirails system architecture and data exchange**57

 - 3.4** **Plans for the roll-out of Europtirails**.....58

- 4** **Signalling installations:
the “Integrated European Signalling System“ INESS**.....59
 - 4.1** **The precursor ERRI project “Harmonisation of Functional Conditions
of Signalling Systems”**59

 - 4.2** **The precursor UIC project “Eurointerlocking”**.....59

 - 4.3** **The European project INESS**.....64
 - 4.3.1 Call for a 7th FP project “Delivering ERTMS-compliant interlocking systems”64
 - 4.3.2 The new project INESS (Integrated European Signalling System)65
 - 4.3.3 Considerations on the future signalling system architecture.....67

- 5** **Train control-command: the ETCS developments**69
 - 5.1** **ETCS project history**.....69
 - 5.1.1 Introduction69
 - 5.1.2 Initial studies, technological choices and preliminary specifications
1989 - 199570

5.1.3	Mandatory specifications, tests and pilot applications, early commercial applications 1996 - 2002	73
5.1.4	Commercial roll-out since 2003	80
5.2	ETCS functionality	81
5.2.1	Characterisation of ETCS.....	81
5.2.2	Functional Requirements Specification FRS	83
5.2.3	Operational modes and related procedures.....	87
5.3	ETCS system description	90
5.3.1	ETCS Multi-level system architecture	90
5.3.2	ETCS system principles	96
5.3.3	ETCS language.....	103
5.4	ETCS subsystems	107
5.4.1	Eurobalise transmission system	108
5.4.2	Euroloop transmission system	111
5.4.3	Lineside Electronic Unit.....	111
5.4.4	Radio Block Centre.....	112
5.4.5	ETCS on-board system	113
5.4.6	ETCS Driver Machine Interface DMI	113
5.5	ETCS application, simulation, validation and certification	115
5.5.1	Strategies for migration from legacy systems towards ETCS.....	115
5.5.2	ETCS simulation tools.....	122
5.5.3	Validation and certification.....	126
5.6	Ongoing further development of ETCS	134
5.6.1	Pilot application of ETCS level 3 with ERTMS Regional in Sweden	134
5.6.2	The new Baseline 3 for the System Requirements Specifications	138
6	Railway communication: the GSM-R developments	145
6.1	GSM-R project history	145
6.1.1	The way to GSM-R	145
6.1.2	The EIRENE and MORANE projects.....	145
6.1.3	The GSM-R project of UIC	146
6.2	GSM-R legal base and specifications	147
6.2.1	Legal base for GSM-R	147

Contents

6.2.2	GSM-R general characteristics and specifications.....	148
6.2.3	GSM-R frequency band	149
6.3	GSM-R functionality and system architecture	150
6.3.1	GSM-R functionality	150
6.3.2	GSM-R system architecture	153
6.4	GSM-R components	154
6.4.1	GSM-R mobiles and handhelds	154
6.4.2	Dispatcher terminals	157
6.4.3	Radio part of GSM-R networks	157
6.4.4	Network Switching System NSS	157
6.5	GSM-R applications and engineering	160
6.5.1	A single platform for all railway service communication needs	160
6.5.2	Specific requirements for the ETCS data transmission	163
6.5.3	GSM-R test and validation	164
6.6	Further development of GSM-R	165
6.6.1	Lessons learnt from implementation and operation of GSM-R	165
6.6.2	Ongoing further developments	167
7	ERTMS implementations	169
7.1	European ERTMS applications in commercial operation	169
7.1.1	Overview	169
7.1.2	Austria	171
7.1.3	Belgium	173
7.1.4	France	174
7.1.5	Germany	176
7.1.6	Great Britain	177
7.1.7	Hungary	178
7.1.8	Italy	179
7.1.9	Luxembourg	181
7.1.10	Netherlands	182
7.1.11	Norway	183
7.1.12	Spain	184
7.1.13	Sweden	185
7.1.14	Switzerland	186

7.2	Programme for European ERTMS corridors	189
7.2.1	ERTMS priority corridors.....	189
7.2.2	ERTMS projects in middle and south east Europe.....	191
7.3	ERTMS implementations outside Europe	193
7.3.1	Overview.....	193
7.3.2	Sydney region in Australia.....	193
7.3.3	China.....	195
7.3.4	India.....	196
7.3.5	Saudi Arabia.....	197
7.3.6	South Korea.....	197
8	Potential for benefits with ERTMS	199
8.1	General	199
8.1.1	Opportunities from standardisation.....	199
8.1.2	Open market for procurement.....	200
8.1.3	Conflicting aspects and interests during the migration phase.....	201
8.2	Interoperability	202
8.2.1	Universality for all kind of train services.....	202
8.2.2	Technical interoperability.....	202
8.2.3	Operational interoperability.....	202
8.3	Safety aspects	203
8.3.1	Safety requirements for ETCS in Full Supervision mode.....	203
8.3.2	Additional national safety requirements.....	206
8.3.3	Compliance with ERA requirements.....	207
8.3.4	Safety requirements for ETCS in Limited Supervision mode.....	208
8.3.5	Lessons learned in the field, conclusions.....	210
8.4	Influence on ETCS on the capacity of lines	211
8.4.1	Introduction.....	211
8.4.2	Calculation of the influence of ETCS on the capacity consumption.....	212
8.4.3	Line capacity for typical cases of lines.....	219
8.4.4	Comments to the results, conclusions.....	223
8.5	Costs and economic evaluation	224
8.5.1	Qualitative considerations.....	224
8.5.2	Benchmark based on life cycle costs.....	225

Contents

8.5.3	Key Performance Indicators	229
8.5.4	Benchmark of life cycle costs and key performance indicators	232
9	Conclusions and outlook	235
9.1	Current ERTMS status	235
9.1.1	Consolidation reached end 2008	235
9.1.2	Formally decided further developments until 2012	236
9.2	Longer term perspectives	237
9.2.1	On-board ETCS and GSM-R	237
9.2.2	Track-side ETCS and INESS	239
9.2.3	Radio communication	240
9.3	On the way to a global de facto standard for train control and communication	241

Appendices

The Authors	243
Glossary	247
Keywords	257

Preface by the Chairman of the UIC ERTMS Platform

The development of ERTMS under the patronage of the European Commission began in 1989 in the context of plans for a European high-speed railway network. This year we celebrate 20 years of work in this area, together with all the contributions of the people who have worked on the project to successfully overcome the problems of expanding and bringing to maturity the main ERTMS sub-systems ETCS and GSM-R. In terms of traffic management, the roll-out of the Eurotrails concept is in full swing. Concerning signalling, a comprehensive European project entitled "Integrated European Signalling System" comprising 30 partners from railways, manufacturers and academia started in October 2008 in order to Europeanise the ERTMS project's last frontier.

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
Michele Elia

Málaga, 31 March 2009

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Thank you, Peter.



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.

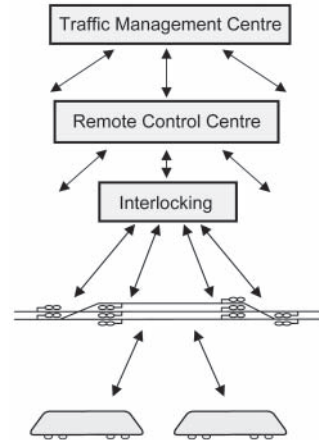


Figure 1.1: Functional structure of the rail traffic management system

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.

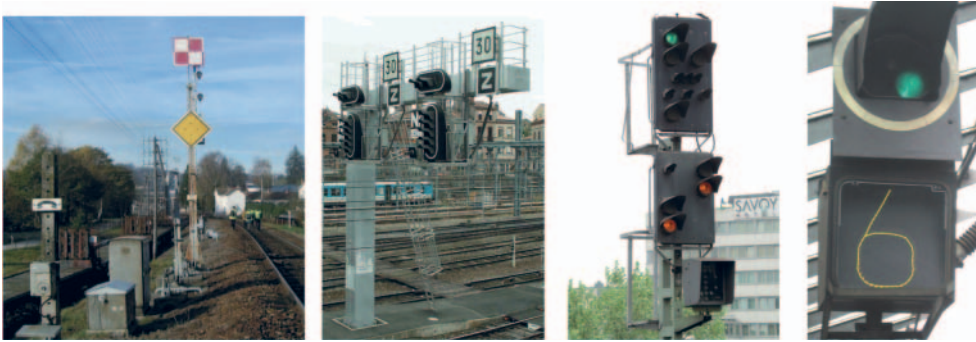


Figure 1.3: Examples of lineside signals

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.



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 table 1.6 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

1 Introduction

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	intermittent/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	discontinuous/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

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

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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	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 (micro-wave)
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
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ERTMS development under the patronage of the European Commission started in 1989 as part of the plans for a European high-speed railway network.

This large Europeanising process is leading to an in depth reform of the railway system. Key driving factors are interoperability in the context of open access to infrastructure, the maintenance of safety and enhancing the performance of train operators. Competition has resulted in an open multi-vendor market for procurement, requiring enhanced cost efficiency over the whole life cycle of the system. After a long history of national traditions in rail traffic management, a new harmonised European concept is becoming a reality. This combines innovative approaches in technology and processes with the underlying rules and regulations governing safety and capacity.

In this book a team of authors, all of whom have been actively involved in ERTMS development for many years, give a detailed description and analysis of the current situation. This includes consolidation with the new baselines for the ETCS and GSM-R specifications, which have now been formally decided.

This compendium is intended to guide the reader through the complex ERTMS concept by giving an overview of all relevant sub-projects. It is hoped that it will help to improve understanding of the concept and so facilitate its further implementation. This in turn will render the railway of the future more attractive and competitive.

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ERTMS development under the patronage of the European Commission started in 1989 as part of the plans for a European high-speed railway network.

This large Europeanising process is leading to an in depth reform of the railway system. Key driving factors are interoperability in the context of open access to infrastructure, the maintenance of safety and enhancing the performance of train operators. Competition has resulted in an open multi-vendor market for procurement, requiring enhanced cost efficiency over the whole life cycle of the system. After a long history of national traditions in rail traffic management, a new harmonised European concept is becoming a reality. This combines innovative approaches in technology and processes with the underlying rules and regulations governing safety and capacity.

In this book a team of authors, all of whom have been actively involved in ERTMS development for many years, give a detailed description and analysis of the current situation. This includes consolidation with the new baselines for the ETCS and GSM-R specifications, which have now been formally decided.

This compendium is intended to guide the reader through the complex ERTMS concept by giving an overview of all relevant sub-projects. It is hoped that it will help to improve understanding of the concept and so facilitate its further implementation. This in turn will render the railway of the future more attractive and competitive.

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