Payment Means covers any transaction that takes payment or establishes credit with a TICS service provider. Cash transactions may prime an electronic purse or debit from the purse. These transactions occur at will and any time a Traveller actor makes an up front payment. Each resource use (or fare) met by credit
payment involves transactions of two use cases. Vehicle Charges (or Fare Collection) set the accounting at the start. Payment Transaction is invoked at the end of service. There is dependency on the Event Class for processing payment violations. The Roadway Class is dependent on the Payment Class for all transactions, which involve payment for use of resources. Operations of the Vehicle Interfaces class provide the payment means for vehicles. Operations of the Travel Terminals class support other Traveller Payment. Operations of the Operating Interfaces class provide interface to the Financial actors.

5. CONCLUSIONS

Use of the UML ensures that one comprehensive model and general methodology can be used for the development of architecture and standards through to the actual implementation of ITS software and systems in the transport network. Thus:

- Every complex system is best approached through a small set of nearly independent views of a model - no single view is sufficient;
- Every model can be expressed at different levels of fidelity; and
- The best models are connected to reality.

Therefore it is proposed to adopt a methodology based on UML for documenting the Slovak Reference Architecture being created. A commercially available CASE tool is to be used to implement this approach. The work has partially been supported by the Grant Agency of the Slovak Republic VEGA, grant No. 1/0444/04 “Theoretical Foundations for Implementing e-Safety Principles into Intelligent Transportation Systems”.

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9. European ITS Framework Architecture Overview (D 3.6) Issue 1, August 2000

1. ISSUES OF ERTMS IMPLEMENTATION AT THE POLISH RAILWAYS

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Summary

Short Description of ERTMS system. Legal conditions of ERTMS system implementation on Polish Railway. Implementation Study of the Pilot ERTMS Installation for E-20 Warszawa-Konin line. Trans-boundary section of ERTMS on the E-65 line Katowice – Bemini. Necessity of ERTMS implementation with pilot sections. Proposals of pilot sections at PKP.

1. GENERAL DESCRIPTION OF ERTMS SYSTEM

European Railway Traffic Management System (ERTMS) consists of the subsystems: European Train Control System (ETCS), Radio transmission system GMS-R (and European Train Management Layer ETML).

1.1. ETCS (European train control system)

The basis for development of an ETCS system is a complex of design specifications, resulting mainly from social conditions. These specifications ensure interoperability of ETCS equipment manufactured by various suppliers. They define functions, procedures, performance ratios as well as ETCS system architecture and relations between various subsystems that are important for assurance of the interoperability. Individual suppliers are free to select optimum technical equipment. The ETCS system is characterized by modular structure, which enables engineering, modernization and construction of various modules at any time using the available techniques.

Such definition of the structure makes possible the expansion of ETCS concept. In the future, the management of strict control of revisions to the ETCS specifications shall ensure firstly maintenance of primary interoperability objective and secondly: the possibility of directional development of ETCS system.

1.1.1. Architecture of etcs

The specification of ETCS system requirements is described by a so-called core of European ETCS with its interfaces to: radio system GMS-R, line traffic protection systems, on-board train equipment. Overall functional structure with links between system core and interfaces is shown on Fig. 1. The onboard equipment – Eurocab ETCS contains transmission equipment and antenna for data exchange with the trackside: Eurobalise, Euroloop, digital GMS-R device and equipment linking with Euroradio. The trackside ETCS equipment contains data transmission equipment using balises, loops or GMS-R, as well as additionally various types of interfaces linking with the fixed installations of railway traffic equipment.

Fig. 1. Functional structure of ETCS.

1.1.2. Available application levels

The ETCS project shows advantages of 3 application levels for ETCS that may be determined using the following features:

- A way to raise the standard, especially in relation to the onboard equipment (it is possible to start the system up using level 1, and subsequently introduce level 2 or even level 3 within the same system specification),
- Backwards compatibility (such as train level 2 may also travel on the line level 1, etc.),
- Consistent system behavior,
- Minimum expenditures.

1.2. GMS-R

GSM-R is a railway version of GSM (R – Railway) operating in the band of 900 MHz. GSM-R functionally corresponds to GSM 2+ making available to the users, besides talk channel, also the following features:

- A digital radio channel for data transmission,
- Group calls, determination of call priorities, function therefore allowing using for example train numbers), and
- Other specialized functions designed for such services as railways or police. GSM-R constitutes then a transmission carrier whereby drive clearances are sent.

Fig. 1. Functional structure of ETCS.
issued by Radio Block Centre – RBC to specific trains located within one RBC area.

Location of GSM-R in the ERTMS/ETCS system is shown on Fig. 2.

![Fig. 2. Place of GSM in the ERTMS/ETCS system.](image-url)

Architecture of GSM-R system is a typical GSM cellular network and consists of a main Network Switching Subsystem (NSS) and Network Management Subsystem (NMS) on the main level and Base Station Subsystem (BSS) consisting of peripheral groups of Base Station Controllers (BSC) and peripheral groups of Base Transceiver Stations (BTS).

GSM-R constitutes the transmission medium not only for ETCS but also for train radio-communication, as it makes available also talk channels. At the same time, spreading of GSM-R gives medium for all other applications, related with information transmission for the purposes of maintenance, statistics, travellers information etc.

2. LEGAL CONDITIONS OF ERTMS IMPLEMENTATION

Implementation of ERTMS (on Polish railways among others) is conditioned by the following acts of European Union:

- Directive 2001/16/EC of 19 March 2001 „On interoperability of Trans-European system of conventional railways”;
- Directive 96/84/EC of 23 June 1996 „On interoperability of Trans-European system of high speed railways”;
- Decision 2001/260/EC of 21 March 2001 on basic parameters of control system containing specifications ERTMS/ETCS and ETMSTM/ETCS MR, supplement directive 96/84/EC;
- replaced by decision 2002/731/EC of 30 May 2002 „On technical specification for interoperability for the subsystem of trans-European system of high speed railways”

Directives 96/84/EC and 2001/16/EC impose on railways of EU member countries an obligation to ensure interoperability of railways. This may be achieved, among others, by implementation of ERTMS system on these railways (through implementation of control subsystem interoperability components denined in the decision 2002/731/EC covering the trackside and onboard equipment of ERTMS/ETCS and ERTMS/GSM-R). Detailed specifications concerning ERTMS/ETCS and ERTMS/GSM-R are contained in the documents named in Appendix A to the decision 2002/731/EC.

Implementation acts are also AGC and AGTC contracts signed by RP government.

3. PROJECTS REALIZED FOR PKP

3.1 Implementation study of e-rtems pilot installation on the line E-20 Kunowice - Warszawa

In the period 1998-1999 an implementation study was made for pilot installation of ERTMS on the line E-20 Kunowice – Warszawa, financed from EU resources.

The advantages were determined in relation with ERTMS implementation, that depend on parameters and characteristic features of the configuration, and namely:

- reduction of border crossing time,
- a possibility to reduce number of drivers working in the train simultaneously, which entails cost reduction,
- reduction of maintaining costs related with lack of need to change the locomotives at the border,
- shortened travel time on certain sections of the line,
- reduced energy consumption,
- integration of specific features of signaling and control at E-20 line with the EU standards,
- increase of throughput at certain line sections,
- increased traffic safety,
- easier future implementation of the system.

Advantages related with all modernization work on the line also were described (tracks, traction, elimination of turnouts etc.). i.e.

- transfer from road to railway transport,
- increased traffic safety because of a lesser probability of road accidents,
- reduced travel time and consequently reduced costs of transport,
- improved environment conditions,
- local and overall advantages,
- specific macroeconimical analysis,
- integration of Polish transport system with Western high speed railways of Europe’s one.

The preliminary scope of the project included:

- collection of necessary data for the line,
- selection of required functions ERTMS/ETCS,
- technical analysis of feasible ERTMS solutions.

The result of the preliminary project phase realization the following issues were proposed:

- ERTMS functions required by CD and PKP (in accordance with Annex 4.29).
- implementation of ERTMS on railway control system systems,
- impact of ERTMS implementation on traffic management.

Table 1 shows the net present values (1997) for configurations taken for calculation.

<table>
<thead>
<tr>
<th>CONFIGURATION</th>
<th>ADVANTAGES (ECU)</th>
<th>COSTS (ECU)</th>
<th>NET VALUE (ECU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 without update</td>
<td>25,007,000</td>
<td>30,400,000</td>
<td>-5,400,000</td>
</tr>
<tr>
<td>Level 2 with update through Euroloop</td>
<td>30,017,000</td>
<td>35,835,000</td>
<td>-5,818,000</td>
</tr>
<tr>
<td>Level 3 with update through euroloop</td>
<td>70,268,000</td>
<td>59,694,000</td>
<td>+10,574,000</td>
</tr>
<tr>
<td>Level 4 with update through KHP</td>
<td>63,622,000</td>
<td>33,649,000</td>
<td>+29,973,000</td>
</tr>
<tr>
<td>Level 5</td>
<td>77,559,000</td>
<td>66,483,000</td>
<td>+11,076,000</td>
</tr>
<tr>
<td>Level 6</td>
<td>82,342,000</td>
<td>89,669,000</td>
<td>-7,327,000</td>
</tr>
</tbody>
</table>

A financial analysis was also carried out for two selected configurations (No 3 and No 6). Annual costs and revenues (cash flow) used in the financial model consists of costs and revenues estimated as a difference between the reference case and the modernization option, taking the costs below into account: cost of delivery, installation and maintenance of equipment,
- cost of trackside and onboard equipment maintenance.

The financial assumption was that the railway projects are investment projects to repay themselves in a long-term time horizon, which means that the modernization projects will require financial resources with long-term reimbursement period. For the financial planning purpose it was assumed that the 50% of financial resources necessary for this investment project will be provided by European Union’s PHARE fund.

Also a possibility of revenues from lease of optical cable to the external operators was taken into consideration. The financial resources with lease and 50% EU contribution in the investment cost (ECU-1997) for the selected configuration is shown below:

<table>
<thead>
<tr>
<th>EIRR (%)</th>
<th>net present value</th>
<th>Benefit/cost ratio</th>
<th>Break-even year</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.49</td>
<td>21,974,000</td>
<td>1.79</td>
<td>2060</td>
</tr>
</tbody>
</table>

3.2 Bohumín - Katowice project

The first trans-boundary project (Poland – Czech) of ERTMS implementation under partial financing of UIC and UE railways PKP and ČD.

The preliminary scope of the project included:

- collection of necessary data for the line,
- selection of required functions ERTMS/ETCS,
- technical analysis of feasible ERTMS solutions.

As a result of preliminary project phase realization the following issues were proposed:

- ERTMS functions required by ČD and PKP (in accordance with Annex 4.29),
- implementation of ERTMS on railway control system systems,
- impact of ERTMS implementation on traffic management.

4. PILOT INSTALLATIONS

Within the works of Technical Group for ERTMS at PKP it was stated that the widespread implementation of the system on PKP should be preceded by implementation on the pilot section.

This solution is supported by the following factors: all European railways implement their ERTMS/ETCS with pilot installations; this is true also for other railways.

Moreover, this solution is supported by the following argumentation:

- adaptation of PKP rolling stock (locomotives) to the cooperation with ETCS;
- a need to check the cooperation of ETCS with the rolling stock remaining on PKP inventory (this applies above all to the locomotive equipment),
- adaptation and verification of STM for SHP and Radiotop;
- preparation and verification of interfaces between the operating railway control systems and ETCS;
- preparation and verification of interfaces between the operating railway control systems and ETCS;

4.1 Proposed pilot sections

The following project have been taken into consideration for pilot installation:

- Line E 65 – section State Boundray – Zabrydowski Katedral
- Line E 65 – section Góra Włoska – Kapiętowa
- Line E 60 – section legionis – Weglinie
- Experimental Track in Zmiędz – test and training section.

Table 2 shows specification of certain features of these sections.

Parameter | Length (km) | Acceptable speed km/h | Equipping with railway control system equipment |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Section I</td>
<td>78,600</td>
<td>120/120 (target 160)</td>
<td>mechanical relay, electronic relay, mechanical relay, electronic relay, mechanical relay, electronic relay</td>
</tr>
<tr>
<td>Section II</td>
<td>46,100</td>
<td>160 (target 200)</td>
<td>mechanical relay, electronic relay, mechanical relay, electronic relay, mechanical relay, electronic relay</td>
</tr>
<tr>
<td>Section III</td>
<td>71,000</td>
<td>65 (target 160)</td>
<td>mechanical relay, electronic relay, mechanical relay, electronic relay, mechanical relay, electronic relay</td>
</tr>
<tr>
<td>Section IV</td>
<td>7,710</td>
<td>120</td>
<td>mechanical relay, electronic relay, mechanical relay, electronic relay, mechanical relay, electronic relay</td>
</tr>
</tbody>
</table>

Table 2. Specification of the sections.

Number of stations | 15 | 3 | 8 | 1

Sections I - III are planned for equipping with 2 level ERTMS and are provided for:
- gaining experience in operation of trackside equipment ETCS level 2.
3. PROJECTIONS REALIZED FOR PKP

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In the period 1998/99 an implementation study was made for pilot installation of ERTMS on the line E-20 Koniniec - Warszawa, financed from EU resources.

The advantages were determined in relation with ERTMS implementation, that depend on parameters and characteristic features of the configuration, and namely:
- reduction of border crossing time,
- a possibility to reduce number of drivers working in the train simultaneously, which entails cost reduction,
- reduction of maintaining costs related with lack of need to change the locomotives at the border,
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- reduced energy consumption,
- integration of specific features of signaling and control at E-20 line with the EU standards,
- increase of throughput at certain line sections,
- increased traffic safety,
- easier future implementation of the system.

Advantages related with all modernization work on the line also were described (tracks, traction, elimination of turnouts etc.) i.e.
- transfer from road to railway transport,
- increased traffic safety because of a lesser probability of road accidents,
- reduced travel time and consequently reduced costs of transport,
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- better social and overall advantages,
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Decision 2001/260/EC of 21 March 2001 on basic parameters of control system containing specifications ERTMS/ETCS and ERTMS/ GSM-R,
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- cost of trackside and onboard equipment maintenance.

The financial assumption was that the railway projects are investment projects to repay themselves in a long-term time horizon, which means that the modernization projects will require financial resources with long-term reimbursement period. For the financial planning purpose it was assumed that the 50% of financial resources necessary for this investment project will be provided by European Union’s PHARE fund.

Also a possibility of revenues from lease of optical cable to the external operators was taken into consideration. The financial resources with lease and 50% EU contribution in the investment cost (ECU-1997) for the selected configuration is shown below:

<table>
<thead>
<tr>
<th>EIRR (% ratio)</th>
<th>economic internal rate of return</th>
<th>NPV – net present value</th>
<th>Benefit/cost ratio</th>
<th>Break-even year</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.49</td>
<td>21,974,000</td>
<td>1.79</td>
<td>2006</td>
<td></td>
</tr>
</tbody>
</table>

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As a result of preliminary project phase realization the following issues were proposed:

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Table 1 shows the net present values (1997) for configurations taken for calculation.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Advantages (ECU)</th>
<th>Costs (ECU)</th>
<th>Net Value (ECU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Level 1 without update</td>
<td>25,007,000</td>
<td>30,406,000</td>
<td>-5,406,000</td>
</tr>
<tr>
<td>2 Level 1 with update through railway lines</td>
<td>30,017,000</td>
<td>35,835,000</td>
<td>-5,818,000</td>
</tr>
<tr>
<td>3 Level 1 with update through loop control</td>
<td>70,268,000</td>
<td>59,694,000</td>
<td>+10,574,000</td>
</tr>
<tr>
<td>4 Level 1 with update through KHS</td>
<td>63,220,000</td>
<td>39,649,000</td>
<td>+39,973,000</td>
</tr>
<tr>
<td>5 Level 2</td>
<td>77,559,000</td>
<td>66,483,000</td>
<td>+11,076,000</td>
</tr>
<tr>
<td>6 Level 2 + 1 Level 1</td>
<td>82,345,000</td>
<td>89,669,000</td>
<td>-7,324,000</td>
</tr>
</tbody>
</table>

4. PILOT INSTALLATIONS

Within the works of Technical Group for ERTMS at PKP it was stated that the widespread implementation of the system on PKP should be preceded by implementation on the pilot section.

This solution is supported by the following factors:
- all European railways implement their ERTMS/ETCS with pilot installations; this is true also for other railways.
- moreover, this solution is supported by the following argumentation:
  - adaptation of PKP rolling stock (locomotives) to the cooperation with ETCS;
  - a need to check the cooperation of ETCS with the rolling stock remaining on PKP inventory (this applies above all to the locomotive equipment).
- adaptation and verification of STM for SHP and Radiostop;
- preparation and verification of interfaces between the operating railway control systems and ETCS;

4.1 Proposed pilot sections

The following sections have been taken into consideration for pilot installation:

I. Line E 65 – section State Boundary – Zbydłowie Kąt
II. Line E 65 – section Góra Włodawka – Krupińska
III. Line E 30 – section Legnica – Węgliniec
IV. Experimental Track in Zmiędzyrząd – test and training section.

Table 2 shows specification of certain features of these sections.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Section I</th>
<th>Section II</th>
<th>Section III</th>
<th>Section IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length [km]</td>
<td>78.600</td>
<td>46.100</td>
<td>71.000</td>
<td>7.700</td>
</tr>
<tr>
<td>Acceptable speed km/h</td>
<td>120/160</td>
<td>120/160 (target 206)</td>
<td>160 (target 200)</td>
<td>65 (target 160)</td>
</tr>
<tr>
<td>Equipping with railway control system equipment</td>
<td>mechanical, relay, electronic</td>
<td>mechanical, relay, electronic</td>
<td>mechanical, relay, electronic</td>
<td>mechanical, relay, electronic</td>
</tr>
<tr>
<td>Line block</td>
<td>present</td>
<td>present</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

Sections I – III are planned for equipping with 2 level ERTMS and are provided for:
- gaining experience in operation of trackside equipment ETCS level 2.
OPTIMIZATION OF SELECTED RFID SYSTEM PARAMETERS

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Summary This paper describes procedure for maximization of RFID transponder read range. This is done by optimization of magnetic field intensity at transponder place and by optimization of antenna and transponder coils coupling factor. Results of this paper can be used for RFID with inductive loop, i.e. system working in near electromagnetic field.

1. INTRODUCTION

Basic RFID (Radio Frequency Identification) system consists of three parts:
- One or more identification transponders
- Reading device (reader), which enables communication between transponder and host system
- Data processing unit (microprocessor).

Basic electromagnetic field parameters of RFID systems are in Fig. 2, where
- \( R_a \) is loss resistance of transmitter’s antenna coil
- \( L_a \) is transmitter’s antenna coil inductance
- \( C_a \) is serial resonant capacitance of transmitter’s antenna coil
- \( U_{a+} \) is voltage transmitted by the antenna’s coils
- \( L_a \) is transmitter’s antenna coil current
- \( R_b \) is loss resistance of transponder coil
- \( L_b \) is transponder coil inductance
- \( C_b \) is parallel resonant capacitance of transponder coil
- \( U_{b+} \) is voltage transmitted by the transponder coil
- \( I_b \) is transponder coil current
- \( R_b \) is parallel loss resistance of RFID chip
- \( k(x) \) is coupling factor between transponder and antenna coil

Basic electromagnetic field intensity \( H(x) \) at the distance from source is given by:

\[
H(x) = \frac{I_b N_b r_b^2}{2(r_a^2 + x^2)^{3/2}}, \quad [\text{A/m}] (1)
\]

where \( I_b \) is antenna current, \( N_b \) is number of turns and \( x \) is distance from antenna in its axis direction.

FDiC 2002/33/EC of 30 May 2002 constituting "Technical Specifications of Interoperability of Trans-European high speed railway systems" (TSI HS) for control system.


Fig. 1. Basic principle of RFID system with inductive loop.

Fig. 2. Parameters of inductive loop RFID system.

Next analysis deals with maximization of read range, i.e. how
- to determine conditions under which the reader antenna radiated energy is maximum
- to determine conditions under which the voltage induced from reader antenna coil to transponder coil is maximum, or, when the coupling factor \( k(x) \) is maximum.

2. MAGNETIC FIELD INTENSITY OF READER ANTENNA COIL

If the energy and data transfer proceeds in frequency range up to 30 MHz (wavelength more than 10 m), the RFID system works with inductive coupling in near electromagnetic field. Near electromagnetic field lies at distance up to \( \lambda/2 \pi \) from its source (where \( \lambda/2 \pi \) is wavelength). Usually, the near field is being created by circular loop antenna with winding several numbers of turns with radius \( r_b \). The reader’s antenna arranged according to Fig. 3. creates magnetic field with intensity

\[
H(x) = \frac{I_b N_b r_b^2}{2(r_a^2 + x^2)^{3/2}}, \quad [\text{A/m}] (1)
\]

Solving the equation (2), which is derivative of (1)

\[
\frac{dH(x)}{dr_a} = \frac{2 \pi (r_a^2 + x^2)^{1/2} - 3 \pi r_b^2 (r_a^2 + x^2)}{2 (r_a^2 + x^2)^{3/2}} = 0
\]

we can compute that the maximum magnetic field intensity is reached when \( r_a = \sqrt{2} r_b \), i.e. when the radius of reader’s antenna is approximately by 41 % larger than required reading distance (Figs. 4 and 5).

Magnetic field intensity can be increased by increasing of number of turns \( N_b \) and by increasing of current \( I_b \). Fig. 2 shows that the reader’s antenna is serial resonant LC circuit with loss resistance, i.e. the current \( I_b \) reaches maximum on resonant frequency

\[
f = \frac{1}{2 \pi \sqrt{L_b C_b}} \quad [\text{Hz}] (3)
\]