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INITIATING THE IMPLEMENTATION OF ETCS AND GSM-R ON A TEST SECTION ON E 30 LINE

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***Abstract**: The paper deals with research work carried out concerning the project preparation of the both ERTMS components, ETCS and GSM-R systems implementation for the test purpose on the selected section Legnica – Węgliniec – Bielawa Dolna – State Border of the E 30 line. In Chapter 2, the selection factors of the project location are described. The ERTMS test implementation project Feasibility Study components comprising demand analysis, social and economical aims, technical, financial and economic analysis are presented in Chapter 3. The possible project realisation phases are also presented in the paper.*

1. INTRODUCTION

The 2006/964/WE Decision from March 2006 requires ERTMS National Implementation Plans to be submitted to the European Commission. Basing on these plans, the European Commission will develop an ERTMS implementation plan for all EU countries that takes into consideration building international pan-European interoperable rail connections. Most of Member States have already submitted such plans, although the mentioned above decision does not require submission before the 28th September 2007. Earlier submission of the documents is mostly connected with plans of using EU funds for the implementation.

The European Rail Traffic Management System (ERTMS) National Implementation Plan in Poland was elaborated in 2006. The document for the both components of the ERTMS, that is ETCS and GSM-R, defines the approved realisation scenarios (identified concrete sections of specified lines) and time (years) of implementation of both systems. From the conducted analysis for the National Implementation Plan, it unambiguously results the fact that the commercial implementation of the ERTMS system for PKP Polish Railway Lines SA network must be preceded by building a testing section which has been located on a section Legnica – Węgliniec – Bielawa Dolna – Border of the State of E 30 line.

2. PROJECT LOCATION

The planed project is situated in the Dolny Śląsk province, one of 16 provinces in Poland, divided into 4 sub-regions (Jelenia Góra - Wałbrzych, Legnica, Wrocław, Wrocław City), 29 poviats [administrative districts] (including 3 town districts: Wrocław, Legnica and Jelenia Góra) and 169 communes. The project is directly situated on the territory of 4 poviats: Zgorzelec, Bolesławiec, Legnica and Legnica City (on the rights of a poviat). The first two are part of Jelenia Góra - Wałbrzych subregion, and the following Legnica subregion.

The E 30 line has a great importance as the east-west transit line. It integrates Western European countries with Central Eastern European countries and links important industrial, scientific and cultural eastern Germany and southern Polish centres, and then connects them to Ukraine, reaching its capital. On the Polish territory the line connects most important economic regions, such as: Wałbrzych Coal-Basin, Śląsk-Dąbrowa Coal-Basin and 4 large urban centres like: Wrocław, Opole,

Katowice and Kraków. The E 30 line has also a great tourist significance because it runs near important spa and health resort centres located on Sudety and Karpaty Plateau along the Polish – Slovak and Polish - Czech border.

The Legnica – Węgliniec – Bielawa Dolna – State Border section is 84.4 km long. It consists of the following lines and sections:

- line 275: Wrocław Muchobór – Gubinek section from Legnica to Mikłowice;
- line 282: Mikłowice – Żary section from Mikłowice to Węgliniec;
- line 295: Węgliniec – Bielawa Dolna – State Border.

These lines have been modernised with the ISPA program funds support. Within the framework of the works, a redevelopment of the line has been made, thanks to which the exploitation parameters have been risen and new rail traffic signalling equipment has been developed, which is the basic ingredient of the ERTMS system. The realisation of the project is a continuation of the ending modernisation and will consist of developing the ERTMS system, which aims at assuring interoperability (to fulfil the requirements of the EU and national laws) and to raise the safety of traffic operation.

The equipment of the basic layer of rail traffic signalling after the modernisation on the section concerned of the E 30 line can be adapted to co-operate with the ERTMS and it comes from a single manufacturer, what will significantly resolve many technical problems. Mainly it consists in the developments for the needs of the ERTMS interface to the rail signalling equipment of the base layer (station interlocking Ebilock 950, 4-aspect automatic line block SHL-12, axle-counters and level crossing protection equipment with the Top type warning light signals) will be useful for the whole examined section.

The exception to this rule is the equipment on Legnica station (two station interlockings of E type and one station interlocking of PB type) and on Węgliniec station (three station interlockings of E type) to which separate interface for the ETCS needs to be developed.

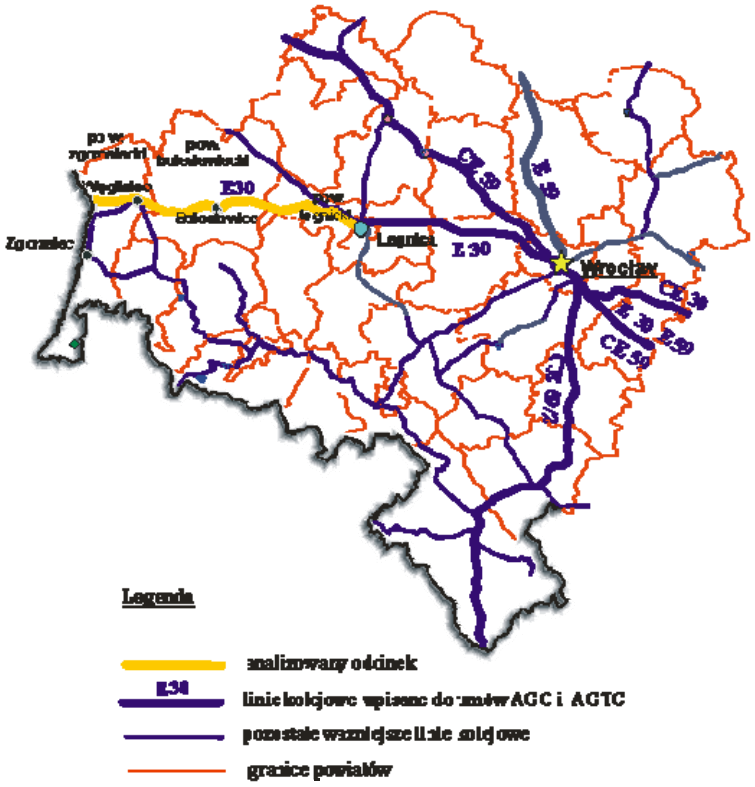

Fig. 1 Project localisation on the background of Dolny Śląsk province

3. FEASIBILITY STUDY COMPONENTS OF THE ERTMS TEST IMPLEMENTATION PROJECT ON THE E 30 LINE

3.1. Demand analysis

In the years 2003 – 2005, a decrease mid-day traffic assignment of passenger and cargo trains on the line E 30 examined in the project was noted. This tendency was possible to be shifted, because in 2005 on some sections an increase of the mid-day traffic assignment of passengers and cargo trains was observed.

In order to establish the detailed flows on line Legnica – Węgliniec, the research on all running trains on the line was conducted. The research of the passenger flow consisted of counting the number of passengers who were inside the train set after departure from the first station of the examined section and the estimated number of passengers getting off the train on particular stations.

The survey counted 612 people total, of which 54,3% were women and 45,7% were men. During the journey, over half of the passengers (69,3%) travelled due to their study or work. This type of journey is serviced by trains running in cyclic mode, and is carried out by a constant group of customers. The rest of the travellers took a trip for personal purposes, recreational – leisure or business ones. This result seems to confirm that the journey often needs to be shaped in reference to a specified type of clients. As far as regional traffic is concerned, it will be the journey to and from workplace or places of study on weekdays, while at weekends and other holidays the timetable should be carried out for potential travel regarding tourism, or the other personal purposes (for example family trips, shopping etc.). Additionally, the questionnaires specified factors that were a part of the travel decision making process. The biggest influence for the examined section was the lack of a different means of transport factor, and then as follows: accessible ticket price, lack of switching stops, short journey time, ease and comfort, security and safety. The questionnaires answered also the question concerning the frequency of travel, for which 60% of the questionnaire respondents travelled everyday and the rest (40%) travelled a few times a month or more rarely. The people travelling by train in a cyclic mode were a strong, in quantity, group of clients, which requires from the carrier mostly: punctuality, invariability of carriage offer and adaptation of the offer to their needs. The second group presumably interested in the comfort of travel, personal safety and security, i.e. factors that the following choice of this type of transport depends on. The fact has to be noticed that encouraging the passengers who have once resigned from rail transport to re-establish usage of rail services is very hard. The questionnaires have also made a choice of the most important factors which should be changed in rail offer. They are, among others: running frequency, punctuality, shortening of the travel time, comfort and ease, ticket prices lowering. In relations where the frequency of connections is lowered (decreased number of trains) a radical decrease of passenger flow follows. Even in case of re-establishing the carriage offer, it is very hard to restore the former state, also in case of operating the proper marketing actions. The carriage market characteristic is that if there is a proper infrastructure, then the gap left after a railway carrier is quickly replaced by bus (microbus) carriers. In consequence, running passenger carriage no longer makes sense.

The passenger carriage forecast has been made based on new technical parameters of the post-modernisation section, assuming an increase of the maximum speed to 160 km/h

While studying passenger carriage by transport forecast on the examined line, the European tendency of increased people mobility due to the increase of national income growth per capita has been taken into consideration.

The biggest increase of the number of passengers will take place in train carriage with qualified and fast trains on long distance – where rail transport offers a higher comfort of travel and a shorter journey time. It is estimated that the increase will be around 22%.

In normal passenger train carriage, the competition of car transport is significant but also here the overall increase will be around 10%. A constant increase of the number of registered cars was taken under consideration, which due to the expenses and the speed of modernisation of roads and development of highways in the forecasted time will not increase a significant comfort improvement of car travel – rather a deterioration and return of passengers to rail transport can be expected.

The basic increase of journeys to work / study places can be expected in the neighbourhood and area of large city agglomerations. Proportionally to forecasted by GUS (Central Statistical Office),

the increase of the number of poviat residents in neighbourhood of city agglomerations.

In the forecasted passenger flows, it was assumed that maintaining the level of passenger flow up to 2010 to be in the level from 2006. Despite the estimated minor decrease of passenger flow in regional carriage, the overall flow will be held at existing annual level (of 566 000 people), regarding the return of qualified trains to the examined section.

3.2. Social and economic aims

The ERTMS system is new in Poland and, so far not implemented. In order to establish a social influence of the project, three basic sources of information have been taken into consideration:

- the experiences of countries, in which this system has already been initiated or tested;
- technical analysis made within the frame of present project, in aspect of significant system functional factors;
- carriage – movement analysis, in the aspect of changing the quality of transport.

The planned investment of test implementing the ERTMS on the of E 30 line section Legnica – Bielawa Dolna –State Border, is not a typical investment for railway transport, such as modernisation of a railway permanent way or rolling stock, where large profits start usually just after its realisation. In case of present project, the test results of the ERTMS introduction are becoming a significant element of further implementation decisions, which allow the verification of separate system elements during their operation and obtain the national certificates. On the other hand, the gained experience allows avoiding mistakes and unfortunate "first step" effects of the new system implementation on the other line sections mentioned in the ERTMS National Implementation Plan.

The ERTMS system operating on the examined section after the end of tests period will bring first benefits specific for this system, which will bear interest along the further implementation of the system on the national network.

The ERTMS implementation on Legnica – Bielawa Dolna –State Border section develops two types of effect: the first –negative, during tests, which can result in passenger and cargo traffic difficulties due to the closing of line sections, and the second – positive, after the tests period, when the benefits characteristic to the ERTMS system will appear. The social benefits result from the following factors:

- increase of punctuality of trains and decrease of delay costs;
- decrease of energy consumption by traction vehicles causing the profits for the beneficiary in the decreased direct costs, but also result profits for the society in decreased external costs due to reduction of the environment pollution thanks to reduced energy production needs;
- decrease of rail accident rate and reduction of external costs of accidents.

The considered section possesses and will posses the line capacity reserves, needed to accept larger traffic. Even small increase of attractiveness of transport services and increasing competitiveness of railways, increases also carriage work and begins positive feedbacks in gaining following benefits. Shorter travel time or lower costs will be an effect of any of the above mentioned points.

Because of the project being located in an over border region, a particularly better – faster and more certain – railway communication can ensure a better integration between the regions on both sides of the border and can contribute to gain synergy effects by optimal usage of resources in both neighbouring countries.

Besides the social benefits mentioned above, achieved due to the improvement of overall transport situation, the other direct social effects will appear in the form of generated work places as a result of the project realisation.

The implementation of ERTMS on Legnica – Bielawa Dolna –State Border section allows also reaching benefits by implementing the system on the following lines, according to the ERTMS National Implementation Plan in Poland. These benefits will be achieved thanks to mistakes avoided in the future, which, however, usually happen due to the pioneer character of the first implementation.

The requirement of implementing ERTMS – according to the 2004/50/WE Directive and Technical Specification for Interoperability for the Control Command and Signalling subsystem – on newly built and modernised lines, realised without a test installation can be related to significant internal and external costs, due to:

- the time lost by the passengers in case of system failure (including secondary delays);
- organisation of substitutive communication and the other temporary solutions, due to traffic organisation changes
- loss of public trust for railways, resulting in:
  - the decrease of rail transport share in modal split, and as the consequence, the increased external pollution, accidents costs, etc.;
  - increase singular costs and the "vicious circle" effect, which can significantly decrease benefits to be achieved due to the modernisation of railway network in Poland.

From the conducted analysis, and from the present other countries' experiences in the field of the ERTMS system implementation, a conclusion can be made that within the planned test project, both social benefits and costs will appear. The costs will be linked to the test phase, and the benefits to the improvement of transport situation in the time of the commercial usage of the system. It is also important to notice that relatively low passenger traffic and quite significant cargo transport on the considered section in recent years on the one side and the forecasted dynamics of carriage growth in the future on the other, causes the circmstances that selecting this location for the test purpose will allow achieving the intended aims, social benefits including . Taking into consideration the aspect of losing time, a conclusion can be made that in a short perspective, the traffic on the examined section is so small that the possible disturbances will be acceptable. In a longer perspective, the implemented ERTMS system on this section can allow social benefits due to a higher volume of realised carriages in a shorter time and of higher punctuality indicator.

The experience of the other railways shows, that the initial system examination on the test section is of great importance for its further effective implementation and exploitation.

The ERTMS is implemented in Poland for the first time. Its testing and usage only on a small fragment of the line, will minimise possible discomforts, accidents or unforeseen events, which if eliminated on this part of the project will not appear during the implementation of the system on other lines of the railway network. Therefore it is forecasted, that the biggest number of benefits will appear due to avoiding a high risk, which may occur on the first implementation of the ERTMS system in the country, which from the social point of view can result mainly in delays and loss of time. In the case of test implementation on the test section of the E 30 line, the risk of significant social costs in case of the system failure is relatively small due to:

- the existence of new railway signalling equipment, providing sufficient capacity;
- relatively low usage of currently available capacity, allowing an effective traffic handling in case of any ERTMS failures.

The elements that also determine benefits are:

- the possibility of handling traffic without any disturbances, even in case of system failure;
- a great usefulness of gained knowledge and experience for the ERTMS implementation on the subsequent lines;
- forecasted carriage dynamics growth on this line, resulting in benefits with usage of the ERTMS after the end of test phase.

3.3. Technical analysis

The Technical Specification for Interoperability of the rail Control Command and Signalling subsystem for the conventional rail system (TSI CCS CR), according to European Commission Decision 2006/964/WE, imposes the ERTMS installation on newly developed and modernised railway lines. The project of the ERTMS development on E 30 line Legnica – Węgliniec – Bielawa Dolna –State Border will be the first to be realised as part of the ERTMS National Implementation Plan for Railways. The railway lines forecasted in the national strategy are the main rail corridors in PKP network, which shall be successively modernised. Although looking at the aimed implementation of the ERTMS, the possible problems should be taken under consideration. The following kinds of problems may occur when the ETCS and GSM-R development starts:

- **Technical**
  The most important problem from the technical side is the realisation of the project. The omission of the ERTMS equipment deployment is equal to disobeying the national and European law, which shows a necessity to ensure the interoperation of railways. The beginning of the process of the ERTMS equipment implementation carries a risk, because incorrect schedules fitting of the development of ETCS and GSM-R can result in blocking the whole investment realisation. The ending of the GSM-R system development as the first will have a positive effect, but if the ETCS is finished first, the investment will not proceed further until the GSM-R system development is finished. Another problem of the technical nature, which needs to be regulated on the project tender stage, is the fact that only companies which have experience in developing such a complex system as GSM-R and ETCS can compete in realisation of the contract, what in practice can cause the delay of the contracted time of the ERTMS system operation commissioning. During the implementation of the system to operation, some problems as the delay of trains may occur, which can be an effect of system tests run.

- **Human resources**
  The ERTMS implementation on the line and the system maintenance requires a prepared staff, that is trained in the range of maintenance and operation of the system. The personnel training requires an intensive training program to be conducted as early as possible in order for the managerial staff to be prepared at the moment of the development and the handing over of the system for tests. The realisation of the test section development project will allow such knowledge by all staff levels comprising management, direct implementation as well as the system maintenance personnel.

- **Procedural**
  The necessity of the national rules of traffic operation and signalling for railway lines equipped with the ERTMS. The national law requires the appropriate certificates and acceptance documents provided by adequate certifying institutions before a system or equipment is allowed for operation. Such documents will also be required for the ERTMS implemented on the Polish railway network. The test implementation of ERTMS and GSM-R will allow gaining these documents before the implementation starts on a large scale. But also here some problems may occur that result from the certification of such a complex system for the first time in Poland. The problem while gaining required certificates may be caused by the research time stretch, for example due to sudden increase of traffic on the test section, which will cause the delay of the contracted time of the complete system operation commissioning. Another group of procedural problems influencing the realisation time of the project are delays in the initiation of the investment process. The delays can be caused by the necessity of receiving necessary permissions and agreements (for example, receiving the construction permit).

- **Financial**
  The most important problem connected with the decision about the ERTMS implementation on Polish territory is the estimation of the ETCS and GSM-R systems adjustment costs to the national conditions (national values, optional functions). If the beneficiary does not receive financial support from the EU, it is highly possible that the project will not be realised.

- **Social**
  The biggest problem that may occur during the process of the project preparation to be realised is the necessity to conduct public consultancies in case of the GSM-R-development. In case of such agreements, a likely protest possibility may occur, especially when construction works start. The risk of protest occurrence may for example influence in a high degree the time schedule of investment realisation. Another question with ERTMS system operation implementation is the possibility of problems caused by train drivers' habits, which obviously can lead to serious delays in bringing the system into operation or, during the operation, it may lead to the timetable delays.

3.4. Financial and economic analysis

Within the Feasibility Study, four alternative designs of ERTMS system implementation have been considered:

The Alternative Design I – minimum (non-investment) assumes a future implementation of the ERTMS on the railway network without checking the system on a test section of the first modernised line. This alternative design is a reference design for the economic and financial analysis.

The Alternative Design II – (investment) contains a test implementation of the ERTMS on a section of E 30 line Legnica – Bielawa Dolna – State Border. The aim of the ERTMS implementation on the test section is to conduct a proper test and research (including co-operation features of system elements and national system). The design assumes initiation of the system to commercial operation.

The Alternative Design III – (investment) contains a test implementation of the ERTMS on a section of E 30 line Legnica – Bielawa Dolna – State Border with a simultaneous construction of a training facility for ERTMS system. The implementation of the ERTMS on the test section aims at conducting a proper test and research (including co-operation features of system elements and national system). After the end of the test stage, the design assumes system implementation to commercial operation and constructed training facility usage to prepare ETCS and GSM-R system implementation for the whole Polish Railway network according to the ERTMS National Implementation Plan in Poland.

The Alternative Design IV – (investment) contains a test implementation to a section of the E 30 line Legnica – Bielawa Dolna – State Border and on Góra Włodowska – Psary – Knapówka section of CMK (Main Railway Line). The aim to implement the ERTMS on both test lines is to conduct a proper test and research (including co-operation features of system elements and national system). This design assumes handing over the system to commercial operation.

In the Feasibility Study, the performed comparative analysis has taken into consideration three alternative designs of the ERTMS test implementations on specified sections, which cost parameters are listed below:

- **for alternative design II:**
  - the investment cost of 38.497.255,51 €;
  - annual operational cost 350.284,03 € up to 2010;
- **for alternative design III:**
  - the investment cost of 42.083.117,27 €;
  - annual operational cost 350.284,03 € up to 2010;
- **for alternative design IV:**
  - the investment cost of 55.957.467,14 €;
  - annual operational cost 437.857,08 € up to 2010.

After the Feasibility Study being conducted, the alternative design II which consists of the ERTMS test implementation on the Legnica – Bielawa Dolna – State Border section of E 30 line was recommended for realisation.

4. PROJECT REALISATION

The aim of the project is to install the ERTMS components, that is ETCS and GSM-R, on Legnica – Węgliniec – Bielawa Dolna – State Border section of the E 30 line for the test purposes and for conducting and checking the STM – Specific Transmission Module for Polish "B class" systems: the SHP – Automatic train braking and the Radio-stop. The system after the end of testing, introduction of possible corrections and reception of proper approvals issued by the UTK (Office for Railway Transport) on the basis of the system owned certificates acceptation, will be passed on for operation. The aims of the tests to be conducted on the E 30 line section are as follows:

- checking the chosen ERTMS functions with the FRS 4.29 (Functional Requirements Specification);
- checking the national variables;
- checking the coding rules for railway signalling equipment in the ETCS;
- checking GSM-R functions chosen from FRS 6.0;
- the development and assessment of interfaces between the operating railway signalling equipment and trackside ERTMS equipment;
- the development and assessment of the STM for the SHP and Radio-stop;
- getting the experience in the GSM-R construction and exploitation;
- checking the ETCS co-operation with rolling stock (especially the onboard equipment);
- gaining experience in the ERTMS/ETCS equipment installation (trackside equipment as well as onboard equipment);

- the managerial staff training for the next implementations of the system on the railway network;
- conducting the ERTMS equipment certification;
- gaining preliminary operation experience with the ERTMS.

The project assumes design, development and activation of the ERTMS equipment on Legnica – Węgliniec – Bielawa Dolna – State Border test section, located on the E 30 railway line, being a part of the III Pan-European Transport Corridor, and also a part of Corridor F.

The ETCS and GSM-R systems will be designed, developed and activated on the test section. The systems are basic elements of the ERTMS. Within the GSM-R project, a network-communication subsystem will be developed along with an intelligent network, which is the basic element of the GSM-R implementation in Poland. To allow transmission, 16 masts for the Basic Transmitting Stations (BTS) will be constructed. To assure communication between user workstations, they will be equipped with 100 communication terminals. In case of development of the ERTMS on the German side of the border, in order to close the transmission loop, a 14 km long fibre optic cable is foreseen to be developed later on the State Border – Węgliniec section. For the ETCS operation, the development of RBC (Radio Block Centre) on Bolesławiec station is planned within the project. To transmit the information from track to vehicles, 1044 non-switchable and 163 switchable balises will be installed, also 31 LEU coders for level crossings will be used. The interfaces to the rail signalling base layer equipment will be designed, made and installed within the project framework (for example, interfaces to the LCS – Local Control Centres, line blocks, level crossing protection). Within the adaptation of rolling stock units to co-operate with the ERTMS, the installation of the ETCS onboard systems and necessary interfaces for their co-operation is foreseen on 8 vehicles, as well as the GSM-R onboard radios in 16 cabins.

The quantity data above are a result of analysis conducted in the Feasibility Study for the test implementation of the ERTMS.

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ЗАПОЧВАНЕ ВНЕДРЯВАНЕТО НА ETCS И GSM-R НА КОНТРОЛЕН УЧАСТЪК ОТ ЛИНИЯ Е 30

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ПОЛША

Резюме: Докладът представя изследване, извършено във връзка с подготовката на проект за прилагането както за на двата компонента на ERTMS, така и на системите ETCS и GSM-R с цел изпитания на избрания участък Легница - Węgliniec - Bielawa Долна - държавната граница на линия Е 30. В раздел 2 се описват факторите за избор на местоположението на проекта. В раздел 3 е представено пробното внедряване на компонентите на ERTMS от предпроектното проучване, което включва анализ на потреблението, социалните и икономически цели, технически, финансов и икономически анализ . В статията са представени също така възможните фази на реализацията на проекта.

Ключови думи: ERTMS, ETCS, GSM-R Systems.