Installation of Rail Traffic Remote Control Systems in Terms of Profitability and Investment Effectiveness

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Abstract. Paper is aimed at analyzing the choice of rail traffic remote control system from the profitability and effectiveness point of view. The analysis was performed for the area of an example railway operator.The paper defines the basic groups of technical criteria for the choice of remote control system and also discusses systems of various manufacturers available on the Polish markets. Investors choose the most effective systems from those offered, according to their needs, technical conditions and financial capabilities. The paper assumes that a project, which is profitable and meets the technical criteria, is considered effective. Article is completed with an example of a practical application of profitability and effectiveness study techniques combined with technical criteria for the installation of rail traffic remote control system within a defined railway area.

Keywords: transport investments, profitability, effecitiveness.

1 Introduction

The choice of optimum investment decision is crucial for the investors, because it leads to a company development. However, precise technical requirements for the given project should be specified to achieve the expected results from the investment.

The process of selecting the proper rail traffic remote control system, from the profitability and effectiveness point of view, is difficult and requires analysing numerous areas: economic-financial, technical and frequently environmental or social areas. The study methods and techniques presented in the paper to a large extent facilitate this process and allow making the most effective choices.

2 Technical Criteria of Selecting the Type of Rail Traffic Remote Control System

The choice of appropriate remote control system for a given railway area depends on many factors. Four groups of criteria may be distinguished, providing the basis for a proper decision on the system selection:

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Group I – Traffic parameters criteria,
Group II – Technical criteria,
Group III – Functional criteria,
Group IV – Quality criteria.

Group I – the basic criterion differentiating the system scope and type consists of planned basic traffic parameters and the fact, whether the railway area appears as a newly constructed or modernised. The basic traffic parameter affecting the system type and hence equipping with the interlocking systems is the running speed limit on the lines (section) under construction or modernisation. Three ranges of speed are distinguished, differing in the required equipment with the interlocking systems [3]:

- up to 160 km/h – effective for the existing or modernised lines, which for various reasons cannot be adapted to higher speeds,
- to 200 or 250 km/h,
- to 300 or 350 km/h – for majority of newly constructed or reconstructed lines, for which the equipment must meet the requirements for the high speed railways system.

Group II – technical criteria, comprising relationships, which should be fulfilled for efficient and safe control of train traffic and of manoeuvres.

Table 1 presents the interlocking systems and groups, with which the work and communication is necessary [3].

Table 1. Technical criteria for interlocking systems and equipment dependence for the work with a rail traffic remote control system. Source: Own study.

System or device specification	Dependence description
Station interlocking (dependence systems)	Computer hardware or a relay device equipped with control panels or interfaces for the work with a master system. Devices should meet appropriate detailed technical requirements, adapted to a specific facility and planned parameters.
Block systems (line interlocking)	Possibility of both-directions working. Up to 160 km/h – automatic block system adapted to work with traffic management systems chosen for the line and with a remote diagnostics system and equipped with recorders of equipment states and traffic incidents. Above 160 km/h and on newly constructed sections – the ERTMS/ETCM system required (level 2); at the traffic of vehicles not equipped with ERTMS/ETCS equipment additionally and automatic block systems, like for speeds up to 160 km/h.
Track non-occupation control systems	The tracks non-occupation control should be executed by jointless track circuits or axle counters, observing the electromagnetic compatibility requirements, in particular the resistance to disturbances generated by the high-speed rolling stock.

Table 1. (*continued*)

Point mechanisms and switching systems	In the main basic tracks – non-trailable point mechanisms. In the main additional tracks – trailable point mechanisms of the holding force required by the regulations, depending on the point switch design, type of interlocking and switching systems used.
Traffic protection equipment on level crossings	The way of roads and pedestrian level crossings with the railway tracks protection should comply with relevant regulations. For speeds above 160 km/h and for newly constructed lines the crossings should be two-level ones. For trains running up to 160 km/h category A and B level crossings are allowed.
Signalling systems	Lines should be equipped with ATP class systems (signal repetition on the locomotive) of ERTM/ETCS train control. Depending on the planned speed limit it is justified to provide with the track-side signals (light signals). The light signals must protect each traffic posts and also stations. The driving acc. to track-side signals may occur at a maximum speed up to 160 km/h, above this speed the driving should be carried out only according to the guidance of on-board instruments for the train control.
Diagnostic systems	The diagnostic system should be adapted to work via interfaces with diagnostic subsystems of individual interlocking systems and devices. It must feature a modular design with a possibility of configuration change depending on the number of monitored objects.
Fire and burglar signalling system	The system should be adapted to a possibility of transferring the information about the existing fire or burglar hazard in objects and equipment working in the area covered by the remote control.
Control station	The computer hardware must satisfy requirements related to the traffic situation and the equipment state visualisation. It should feature a high reliability, a possibility of connecting in networks, a modular design, a possibility to connect with specialised equipment. Appropriate number of interlocking computers.

Group III – functional criteria related to the installed system operation and its maintenance. In this criterion the important factors are related to:

- guarantee servicing by the system manufacturer (the guarantee duration),
- repair and replacement of system subassemblies (subassemblies availability, anticipated subassemblies production time),
- time of response to a defect notification (service location),
- possibility of training for the staff responsible for the system maintenance.

Group IV – quality criteria are strictly related to the obtaining for a specific system the certificate of permanent operation permit, which shows the system users its reliability and observation of appropriate level of traffic safety.

The description of individual groups of criteria shows the complexity of the decision-making process for the remote control system choice both for the newly constructed and modernised lines.

3 Types of Rail Traffic Remote Control Systems Available on the Polish Market

In contemporary conditions an efficient, fast and safe railway requires such rail traffic control systems, which on the one hand – using appropriate documents or signals – provide the vehicle driver with the information about the driving speed and on the other hand enable preparing the routes in a coordinated and collision-free way [1]. The railway managers, in accordance with the needs, technical conditions and financial capabilities, are pursuing modernisation of obsolete rail traffic control systems using the offers of companies present on the Polish market, but also offers of foreign companies, which try to enter the Polish market.

The Bombardier Transportation (ZWUS) Katowice is the best known and experienced company in the rail traffic control sector on the Polish and European market. This company offers a wide range of products starting from modern remote control systems, station computer hardware through block systems and up to automatic level crossing signaling.

The Kombud S.A. Zakład Automatyki from Radom is another manufacturer of interlocking systems known on the Polish market.

Systems of other (foreign) manufacturers are also used in Poland, e.g. the Siemens Sp. z o.o. system or the ALCATEL SEL AG system.

The first of them is a secure microcomputer system, which can be used for small and large areas, for local and main-line services. The latter is a microprocessor switching system.

Because of a great technical progress newer and newer solutions appear in the interlocking systems sector. This applies both to Polish and also to foreign companies. The system of a Czech company PrvniSignalni is an example, which in its development assumptions will be using a wireless (radio) communication to execute the remote control function. Such a solution will allow obtaining substantial savings in the field of cable lines construction, modernisation or maintenance costs. Moreover, it is very important in the case, when the railway infrastructure is situated in the area of active mining subsidence influence. The very cable lines are the most frequently exposed to continual breaking, resulting in systems failures. Cable lines are also very often exposed to theft.

4 Matrix of Technical – Economic Aspects Relationship for the Installation of Rail Traffic Remote Control Systems – Options Hierarchy Setting

The specification by the investor of the investment objective and the investment type is the necessary basis to establish relationships between technical and economic aspects and to hierarchise the options of remote interlocking systems installation. This will allow establishing at the beginning the basic interlocking parameters of technical or economic criteria importance. The assumption is that the investor selects an

effective project, i.e. such which is profitable and meets the technical criteria. The assumptions for individual technical-economic relationships are determined by the investor and broken down to those that must be fulfilled unconditionally and those, which execution is optional.

To assess and choose the most profitable project the profitability examination methods are selected and basic parameters are established, which must be fulfilled unconditionally and then optionally [2].

Table 2. Technical criteria evaluation sheet for four example Projects of rail traffic remote control system installation. Source: Own study.

Criteria	Project I	Project II	Project III	Project IV
UNCONDITIONAL CRITERIA				
Group I – traffic parameters				
Running speed limit - up to 160km/h	1	1	1	1
Group II – technical criteria:				
Computer hardware with interfaces to work with the master system	1	1	1	1
Track non-occupation control executed using axle counters, observing the electromagnetic compatibility requirements	1	1	1	1
Electronic system works and enables using the existing external devices	1	1	1	1
Work with the signalling system	1	1	1	1
Work with the traffic protection equipment on level crossings	1	1	0	1
System diagnostics	1	1	1	1
System operating in the “2 of 3” dependence system	1	1	0	1
Possibility of radio communication	1	0	0	0
OPTIONAL CRITERIA				
Group III – functional criteria				
1 year guarantee period	0	1	0	1
Easy access to components and anticipated period of their manufacture	1	0	1	1
Service location	1	1	0	0
Personnel training	1	1	1	1
Group IV – quality criteria				
System holds a certificate of permanent operation permit	0	1	1	1
It is allowed to carry out field tests to obtain a certificate of permanent operation permit	1	0	0	0

1 means that the specific parameter is fulfilled by the project

0 means that the specific parameter is not fulfilled by the project

There is a similar procedure for the technical analysis, specifying technical parameters, which must be absolutely fulfilled and such, which execution may be optional.

To illustrate the procedure, four different Projects[1] were subject to an example assessment.

Table 2 presents an example of an evaluation sheet in terms of technical criteria for four projects, which will allow eliminating projects not meeting the unconditional criteria and further on which will allow determining the optional criteria fulfilment.

Groups of formerly described criteria were used in Table 2, which will differ depending on the investor needs, the investment objective and the investment type.

Table 2 shows that example Projects I, II, and IV will be subject to further profitability analysis.

Table 3 presents an example of projects evaluation sheet in terms of investment profitability parameters, determined and indicated as unconditional and those, which may be optional. Profitability assessment techniques formerly described were used in the table [2], which will differ depending on the investor needs, the investment objective and the investment type.

Table 3 shows that two projects fulfil the unconditional technical and economic criteria. The selection of the most effective project may be performed using a multi-criteria method in a weighted system, in which optional technical-economic criteria are analysed for projects satisfying the unconditional relationships, assigning them importance in the form of weights. Table 4 presents an example sheet for multi-criteria evaluation in a weighted system. The weights assigned for individual optional parameters reflect priorities of the given investor. The total of all criteria weights should be equal 1. The most effective project is that, which will obtain the highest total score of weighted evaluation. Projects I and II will be evaluated in Table 4.

Table 3. Profitability parameters evaluation sheet for three example Projects fulfilling unconditional technical criteria for rail traffic remote control system installation. Source: Own study.

Criteria	Project I	Project II	Project IV
UNCONDITIONAL CRITERIA:			
Static methods:			
ARR for the investment is higher or equal to a limit rate, determined based on the market interest rate	1	1	1
Dynamic methods:			
NPV should be higher than zero	1	1	0
PI value should be higher than one	1	1	0
OPTIONAL CRITERIA:			
Static methods:			
Investment payback period is shorter than 5 years	1	0	0
Investment payback period is shorter than 7 years	0	1	0

1 means that the specific parameter is fulfilled by the project

0 means that the specific parameter is not fulfilled by the project

[1] Systems names are not important here, although the names and their manufacturers are known to the paper authors.

Table 4 shows that, for the presented example, Project I is the most effective, which implies that Project I is also profitable and meets technical criteria assumed in the example.

5 Analysis of Options of the Rail Traffic Remote Control System Selection for the Identified Railway Area in Terms of Project Profitability and Effectiveness

Possibilities to finance an investment consisting in the modernisation of traffic control equipment via the installation of a rail traffic remote control system were determined based on the current and predicted economic-financial results as well as the investment profitability criteria were determined using the static and dynamic methods. These assumptions and the other parameters necessary do determine the profitability indices are presented in Table 5.

Table 4. Multi-criteria in a weighted system evaluation sheet for two Projects fulfilling unconditional technical-economic criteria for a rail traffic remote control system installation. Source: Own study.

Evaluation criteria	Weight	Project I		Project II	
Optional technical criteria:		Evaluation	Weighted evaluation	Evaluation	Weighted evaluation
1 year guarantee period	0,07	0	0,00	1	0,07
Easy access to components and anticipated period of their manufacture	0,10	1	0,10	0	0,00
Service location	0,05	1	0,05	1	0,05
Personnel training	0,08	1	0,08	1	0,08
System holds a certificate of permanent operation permit	0,10	0	0,00	1	0,10
It is allowed to carry out field tests to obtain a certificate of permanent operation permit	0,10	1	0,10	0	0,00
Optional profitability criteria:					
Investment payback period is shorter than 5 years	0,30	1	0,30	0	0,00
Investment payback period is shorter than 7 years	0,20	0	0,00	1	0,20
TOTAL:	1,00	x	0,63	x	0,50

1 means that the specific parameter is fulfilled by the project
0 means that the specific parameter is not fulfilled by the project

Profitability indices were calculated for parameters assumed in Table 5, using dynamic and static methods.

Evaluation using dynamic methods:

1. Net Present Value (NPV) [calculated acc. to formula (**6**)] at the assumed discount rate of 9.26% is approx. PLN 54,000,
2. Internal Rate of Return (IRR) [calculated acc. to formula (**9**)] is 9.4%.

Formulae for the calculation are provided in [2].

Table 5. Basic data and assumptions necessary to determine the value of investment consisting in the modernisation of the interlocking and in the installation of a rail traffic remote control system. Source: Own study.

Specification	Value, PLN million
Defined maximum value of the investment	15
Maximum own contribution	10
Maximum value of a long-term loan	5
Forecast of annual revenue on sales is based on the historic data and on the analysis of demand for services in further years	Around 26
Cost forecast is based on the historic data	Around 97% of total revenue on sales
Investment depreciation calculated from January 2017 (after the investment completion). The other replacement costs of the investment in the railway infrastructure determined based on the forecast	Approx. 3 million a year
Assumed period of project forecast	5 years

Figures in the table are examples

Evaluation using static methods:

1. Payback Period (PP) [calculated acc. to formula (**1**)] is 3.5 years.
2. Accounting Rate of Return (ARR) [calculated acc. to formula (**3**)] is 33%,
3. Return on Investment (ROI) [calculated acc. to formula (**4**)] is 14.6%.

Formulae for the calculation are provided in [2].

Assuming the achievement of all parameters adopted in Table 5, for the investment of around PLN 15 million (unconditional criterion), the project will be profitable and cost-effective and the company, for the profitability indices assumed in this way, in the future period will feature liquidity, stability and solvency.

Therefore, to consider the project for the determined area effective, its value should not exceed PLN 15 million and it should fulfil the technical criteria specified in the evaluation sheet in Table 2. The value of each of both offers costs does not exceed PLN 15 million.

6 Summary

It results from the information contained in Tables 2 and 4 that only one offer – project I – satisfies all unconditional technical criteria and a majority of optional

criteria. The system does not hold a certificate of permanent operation permit. For the presented considerations a hypothetic assumption was made that the manufacturer carries out tests in the field of the radio communication utilisation in the interlocking control. Such a solution seems to be the optimal. A system based on the radio communication would allow achieving substantial savings in the field of cable pathways construction and maintenance. However, the selection of this system would result in the investment elongation by the time of field tests duration.

Despite the fact, that not all the unconditional criteria were met, it is also possible to consider the acceptance of Offer II, i.e. a system, which holds a certificate of permanent operation permit. But this system is not working with the existing external devices. However, had the company continued considering both projects, it should carry out again a multi-criteria evaluation for them, in which – for specific technical parameters – the weights will be assigned in accordance with the company priorities. A suggestion of assigning weights, acc. to the company assessment, to individual criteria is presented in Table 6.

Table 6. A sheet for multi-criteria evaluation in a weighted system for both offers for the installation of a rail traffic remote control system in the railway area of the company. Source: Own study.

Evaluation criteria	Weight	X		Y	
Functional criteria		Evaluation	Weighted evaluation	Evaluation	Weighted evaluation
Possibility of modular installation	0,10	1	0,10	1	0,10
1 year guarantee period	0,07	1	0,07	1	0,07
Determinable predicted period of components manufacture	0,05	1	0,05	1	0,05
Easy access to various manufacturers components	0,08	1	0,08	0	0,00
Close location of the service	0,07	1	0,07	0	0,00
Personnel training	0,08	1	0,08	1	0,08
Qualitative criteria					
System holds a certificate of permanent operation permit	0,30	0	0,00	1	0,30
It is allowed to carry out field tests to obtain a certificate of permanent operation permit subject to indication premises of system innovation	0,25	1	0,25	0	0,00
TOTAL:	1,00	x	0,70	x	0,60

1 means that the specific parameter is fulfilled by the project
0 means that the specific parameter is not fulfilled by the project

The table shows that the company should accept Offer I, which according to specified technical-economic criteria will be most effective. As the offer predicts field tests, the installation and commissioning of the equipment must be carried out based on relevant agreements and contracts between the interested parties.

7 Conclusion

At present a fast and primarily safe railway is expected. Such parameters may be achieved inter alia by the installation of rail traffic remote control systems. As these are very expensive investments, it is necessary to analyse carefully the area, in which the system is to operate, to specify expectations related to technical parameters and primarily to determine the financial capabilities of the entity, which will become the investor.

Investments related to the installation of rail traffic remote control systems are long-term investments. So for the investor it is important to determine the investment profitability and effectiveness under changing economic-financial or organizational-legal conditions. The undertaken investment risk should adequately balance the technical needs, therefore it is important to carry out profitability and effectiveness analyses for the undertaken projects.

The selection of the most effective project of rail traffic remote control system installation, fulfilling all the profitability parameters and ensuring the implementation of technical conditions, is a difficult but necessary task for the investor.

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