Risks in Investment Processes Covering Railway Traffic Control Systems

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Summary
A significant factor related to investment processes, particularly with reference to railway traffic control systems, is risk. Taking any investment-related decision entails a risk. For this reason, it is necessary to assess the gravity of risk related to the investment process. The article presents selected risks in investment processes which encompass the development of railway traffic control systems. The survey results which show risks at various stages of the investment process are discussed. Additionally, actions aimed at eliminating such risks are suggested.

Keywords: risk, control command subsystem, investment process

1. Introduction

In the last few years, we have recorded an increase in the number of railway investments. The size of undertakings in such a short time is related to the substantial growth in railway investment risk. The article places emphasis on railway investments which involve the implementation of railway traffic control systems (rtcs) because it is primarily the control command system that is responsible for safety in railway transport and, additionally, it is the most complicated subsystem requiring experience and know-how. Pursuant to the directive [2], the structural control command system distinguishes two kinds of subsystems, that is "trackside control – command and signaling subsystem" and "on-board control – command and signaling subsystem". These subsystems were defined as "any trackside devices required to provide safety and railway traffic control" and "any on-board devices required to ensure safety and railway traffic control". The definition of the control command subsystem can also be presented in terms of functions, as a system which is supposed to provide safe control of railway traffic in any conditions; in particular, its task is to prevent head-on train collisions, collisions at railroad turnouts and excessive speed, etc. However, following the act [9], the railway traffic control system is defined as "equipment required to provide safety and railway traffic control on the railway network, along with communication devices and control software".

At present, a series of railway investments intended to raise the competitiveness of railway transport are being implemented. In railway traffic control, we can witnesses more and more investments aimed at implementing new interoperable systems. Pursuant to [3] provided to the European Commission in July 2017, it is anticipated that 2667 km of rail lines will have been equipped with the ETCS system by 2023 in Poland. On top of that, the number will rise more than twice by 2030 to reach over 6700 km. Simultaneously, it is planned to implement the GSM-R system in most railway lines in Poland. The expenditure related to implementation of the ERTMS system in the railway infrastructure in Poland has been estimated to be approx. 6 billion PLN, and most of it will come from EU funds [5].

The investment processes in railway transport are often long-term and costly. When carrying out each investment, many entities cooperate and have an impact on the fulfillment and success of the aforesaid investment. Unfortunately, railway investments are sometimes not completed on a timely basis due to their complexity and difficulties. The late completion of investments is determined by many elements, it may be changes in legal regulations or a lack of cooperation between the contractor and the ordering party. The course and fulfillment of the investment

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influence the safety of traffic control systems and may pose a potential risk.

2. Investment processes on polish railway lines

One of the most important documents related to scheduled investments in railway transport is the long-term National Railway Program [NRP] [4], which embraces investments on railway lines co-funded by the Ministry of Transport. The National Railway Program remains in force until 2023, that is, while it is possible to co-fund projects from the European Union's funds for the years 2014–2020. The document specifies the value and sources of funding (including EU funds and domestic means) and serves as a basis for investment funding in accordance with the public finance law. The National Railway Program replaced the Long-Term Railway Investment Program. The first variant of NRP was adopted by the Council of Ministers on 15 September 2015.

The provisions of the National Railway Program until 2023 [4] specify expenses to the amount of 66.4 billion PLN for 222 projects (Fig. 1).

As stipulated in [9], so far the National Railway Program's projects with a value of about 10 billion PLN have been completed and settled. At present, projects worth 32 billion PLN are being carried out. PKP PLK has agreements for 2/3 of the investments from the NRP, which is over 40 billion PLN. The largest contracts are for the construction of the cross-town tunnel under Łódź and assembly of the GSM-R system (total value of 3.5 billion PLN) carried out in the "design and build" formula and now at the design stage. In turn, other investments are already late. These include modernization of railway line no. 7 from Warsaw to Lublin and modernization of the central section of the main Poznań – Wrocław line [10]. Sadly, delays in the investment affect the quality of the investment and affect safety. The figure 2 below shows the scope of investment funding in the years to come. Most investment costs are covered by the EU. Since EU co-funding is considerable, there is a likelihood that hasty investment planning may influence their rationality.

Many project-related or assembly-related mistakes are detected at the certification stage, which is obligatory in all EU-funded investments. The require-

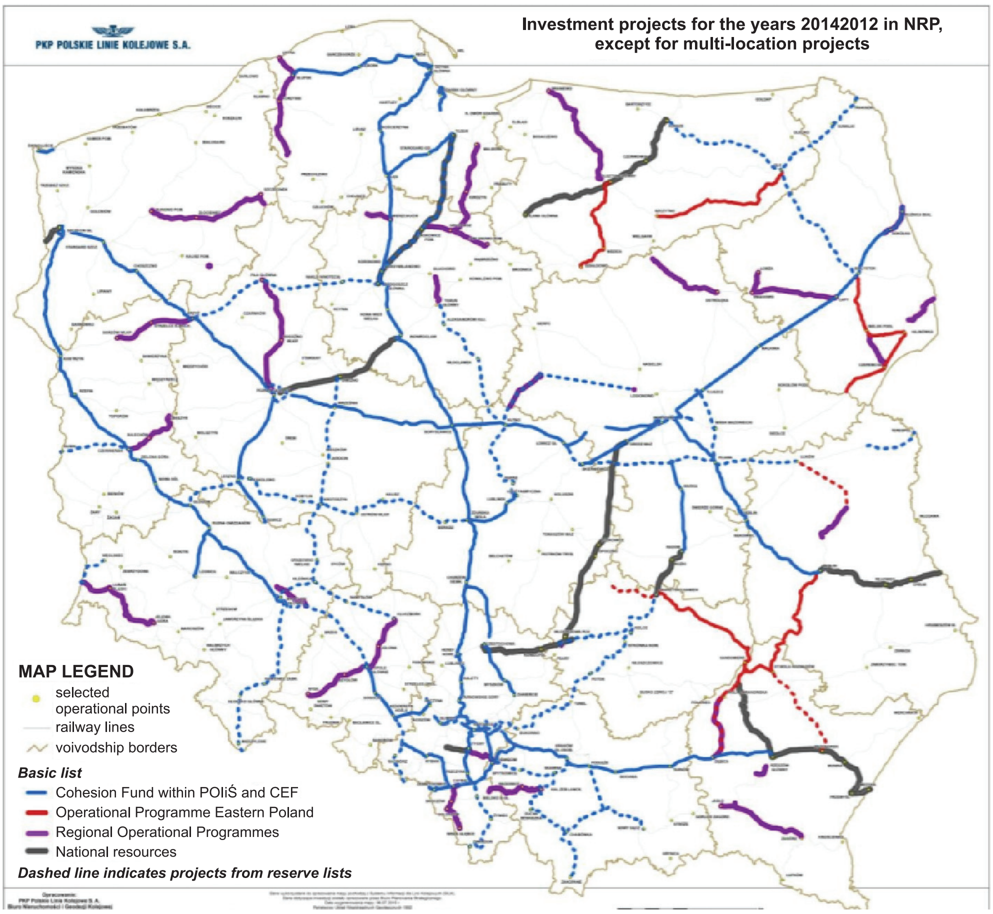

Fig. 1. Infrastructure investments in the Program [4]

ments of Directive 2008/57/CE [2] stipulate that it is necessary for the notified body to certify the subsystems, which determines potential commissioning of the railway line. The certification is to confirm that interoperability requirements, included in Interoperability Technical Specifications, have been satisfied and prove the specific system or subsystem is safe.

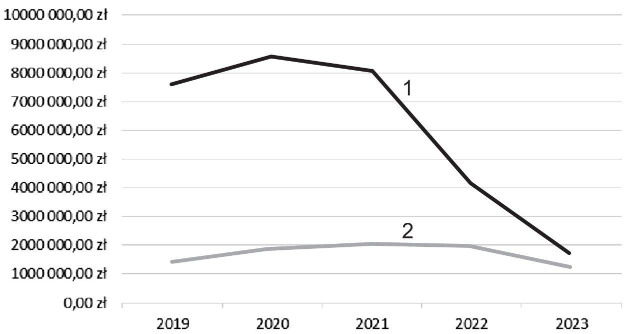

Fig. 2. Planned expenses for EU projects as per target sources of funding: 1) EU funds, 2) Stare budget; own elaboration based on [8]

3. Railway investment processes covering the development of railway traffic control systems

The railway investment process is composed of several stages:

- Specifying needs and elaborating concepts,
- Developing a feasibility study,
- Drawing up documents and obtaining administrative decisions,
- Construction works,
- Inspecting and taking over the investment,
- Settling the project.

Preparing the concept is one of the most important investment stages as it determines its success or failure. It is necessary to define the goal of the investment, method of implementation and related costs, as well as anticipate potential difficulties which may arise during construction. The basic project information is developed during the initial feasibility study. It includes general information on implementation, which must be then made more specific in the design documentation. The feasibility study encompasses a market analysis, technical analysis, strategic analysis and economic analysis. Based on these, order specifications are drawn up. They specify the terms of the investments and expectations from contractors. This information is included in the tender materials used to choose the contractor. The tender usually lasts about 6 months, depending on the complexity of the investment process and subject of the order. Figure 3 depicts the minimum railway investment duration and division into stages.

Most Polish railway lines still have old railway traffic control equipment. In accordance with [3], the rtc devices which do not belong to class-A systems in the Polish railway network include the following:

- about 63% of mechanical lever frames,
- about 30% of electric lever frames,
- about 7% of computer lever frames.

The railway investments which cover the development of railway traffic control systems are more demanding than investments related to other subsystems. Figure 4 below shows a few distinctive features concerning the aforesaid investments.

At present, a series of investments are being implemented. Their task is to develop modern and safe rtc systems and, in particular, it is planned to develop an interoperable ETCS system and GSM-R system. With reference to ETCS, 2480 km of railway lines in Poland are scheduled to be equipped with this system by 2023 (including already equipped sections) [4]. In the years 2024–2030, it is planned to develop ETCS along a distance of 4069 km of railway lines. According to the plan, at the end of 2030 the railway carriers should have 6549 km of lines equipped with the ETCS system. The ETCS system is intended to improve traffic safety, but is not always able to increase traffic capacity on railway lines. There is no doubt that the development and maintenance of the ETCS system are very expensive. The estimated costs of developing the ETCS system, specified on the basis of previous project experience, are as follows [3]:

- 260 000 PLN – costs of implementing ETCS system level 1 per km of line,
- 485 000 PLN – costs of implementing ETCS system level 2 per km of line.

The estimated costs of maintaining the ERTMS system are the following:

- 13 400 PLN – unit cost of maintaining km a year of ETCS system level 1,
- 19 400 PLN – unit cost of maintaining km a year of ETCS system level 2.

In the aftermath of the development of the ERTMS system in accordance with [3], the annual maintenance cost for the sidetrack part of the system will be about 197.2 million PLN.

4. Risks in investment processes

As already mentioned, the implementation of the investment process entails several risks, especially if these are investments related to the implementation

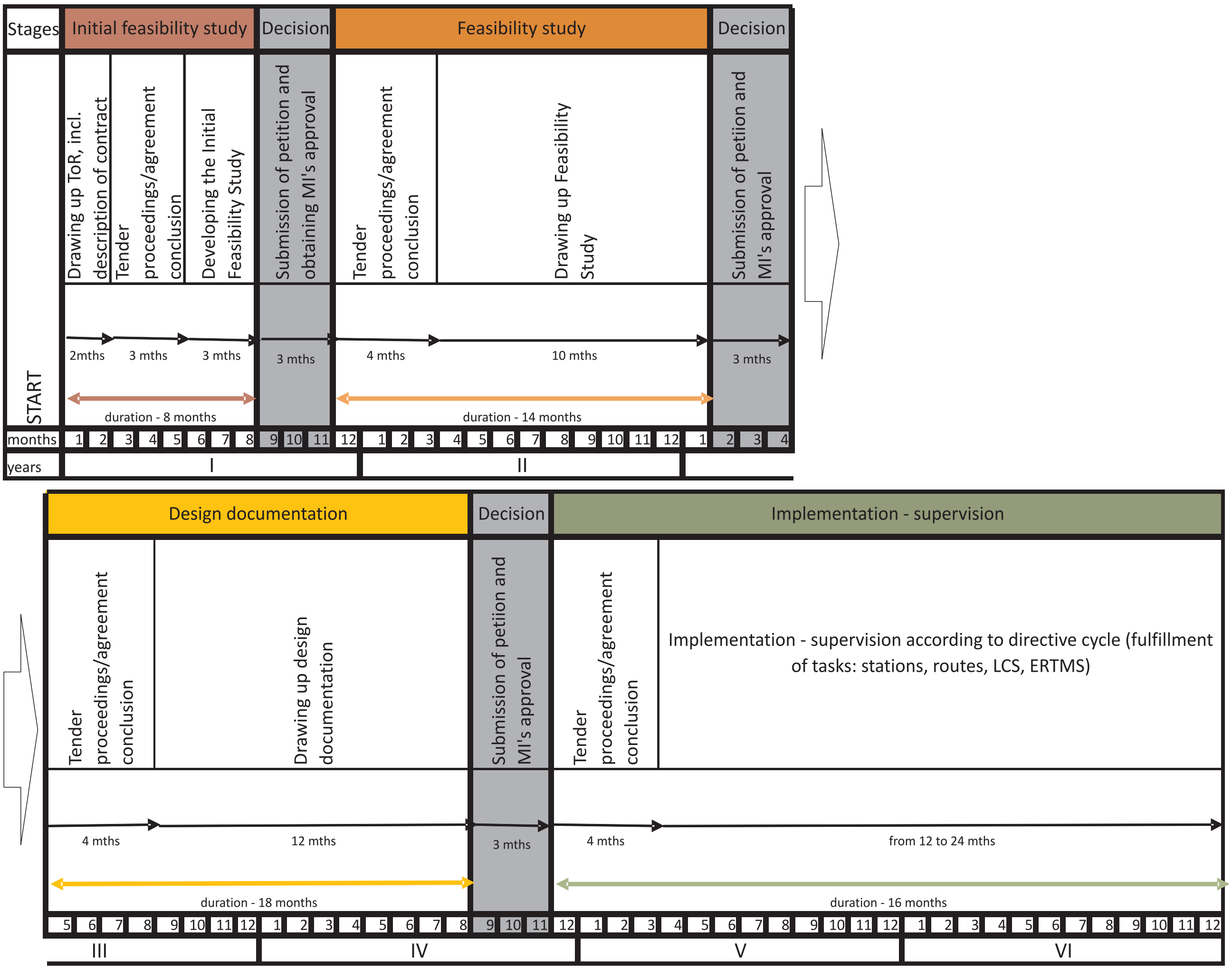

Fig. 3. Investment process duration; own elaboration based on [1]

Fig. 4. Railway traffic control system investment features [own elaboration]

of rtc systems. In order to conduct a comprehensive analysis of risks and hazards in investments related to railway traffic control systems (Fig. 5), railway traffic specialists were surveyed. In response to questions concerning railway traffic control system safety in investment processes, the following threats were the most commonly listed:

- higher material costs,
- incorrect safety proof,
- integration with other railway traffic control systems, that is, a lack of interfaces,
- short investment completion time,
- contractor's lack of legal knowledge,
- lack of experienced and competent engineers,
- complicated processes related to obtaining a usage permit,
- many business partners,
- failure to follow design rulesa reckless approach to technical hazards by inspection units (AsBo – Assessment Body),
- controlling traffic during investment works,
- bad organization of the ordering party's work and no cooperation between the investor and contractors
- negligence during technical approvals (takeovers),
- lack of ordering party's knowledge of systems used in the field,
- price as the main criterion for choosing the contractor, which results in the development of cheaper devices and low quality of manufacturing,
- availability and timely delivery of rtc equipment.

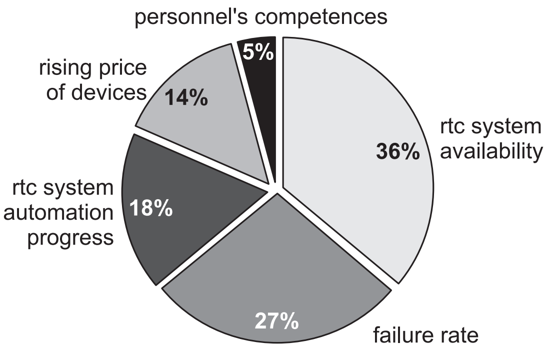

Fig. 5. Risk indicators for railway traffic control systems [own elaboration]

The above-stated hazards listed by the respondents are serious threats which virtually nobody seems to analyze. There are no measures which prevent the appearance of these hazards. It turns out that late implementation of the investment has a considerable influence on safety of the investments related to rtc systems. Sadly, most investments are late, sometimes by as many as a few years. According to the respondents, the investment delay results in the following:

- contractors are forced to implement previously unscheduled solutions related to traffic control,
- pressure and time pressure, which lead to many design-related and assembly-related mistakes,
- aging and deterioration of devices developed (investment delay does not extend the device supplier's warranty),
- rising likelihood of devastation and theft,
- imprecise checks and system tests,
- higher risk of human error,
- adoption of contractual penalties,
- emergency traffic control.

In addition, the number of business partners also influences the safety of railway investment. If there are are several business partners during the investment, there may be difficulties in cooperation and the flow of information. Another issue is the number of railway traffic control device suppliers, because devices which come from various suppliers frequently fail to cooperate, which also requires the elaboration and implementation of interfaces.

One of the main risk factors in railway investments is the human factor. Computer automation systems currently under development can reduce the human factor risk. In spite of this, the human factor has a substantial impact on the investment process at its various stages. Based on the survey results, it turns out that as many as 47% of respondents had never encountered the human factor analysis in investment processes related to railway traffic control systems. The aforesaid result is disturbing because the human factor is the source of risk due to rushing, fatigue and lack of competences.

There are a number of risk analysis methods which include the human factor. The risk analysis methods adopted by the respondents in investment processes are demonstrated in the Fig. 6.

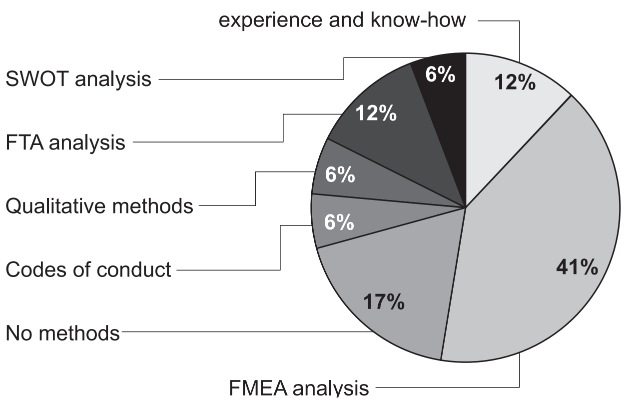

Fig. 6. Risk analysis methods adopted by respondents [own elaboration]

The above-stated results explicitly show that most people from the railway traffic control business primarily encountered the use of the FMEA method (Failure Mode and Effect Analysis). Eventually, when asked about their opinion on whether railway investments related to rtc systems were implemented properly in terms of safety, only 50% of respondents answered yes. Others stated that it was dependent upon the way of implementing the investment (rushing, pressure and lack of cooperation with the ordering party). Many respondents also listed the lack of access to technical documents due to the so-called company's know-how, and this prevents the creation of interfaces between systems. The other threats associated with investment processes include the following:

- changeable legal requirements,
- multi-level document approvals,
- time-consuming consideration of cases by institutions participating in project implementations,
- lack of spatial development plans, which prevents location decisions and building permits from being obtained,
- extensive requirements of local environments in exchange for permits, which leads to higher investment costs [1],
- growth of prices of steel and other metals and materials,
- growth of proposal prices exceeding amounts which PLK intended to spend on contracts, which entails the need to invalidate tenders and repeat procedures, as well as apply for changes in the European Commission's decision with regard to funding (financial memorandum),
- longer tender procedures arising from numerous protests at all stages of the tender procedure,
- limited potential of design offices resulting in a low number of proposals in tenders and late elaborations,
- shortage of qualified staff involved in the implementation process.

5. Risk-eliminating measures in investment processes

The major problem in investment processes related to the development of rtc systems is the lack of competent personnel, which arises from the sudden growth of the railway business in Poland. When implementing railway investments related to rtc systems, contractors must be familiar with and follow the requirements of many legal documents, i.e. norms, resolutions and technical interoperability specifications. The investment contractors or design offices often hire incompetent employees, which translates into design mistakes, or errors at the system development stage. This issue could be eliminated through training/courses intended for young workers. In order to eliminate other risks described in Section 4 of this article, the following are suggested:

- using risk analysis methods at each stage of the investment,
- drawing up tender documentation more accurately,
- estimating costs and completion dates of the investment more precisely,
- adopting new principles for taking administrative decisions in order to make sure they are made earlier,
- developing a universal rtc system interface,
- improving the cooperation between the ordering party and contractors,
- failure to submit to pressure and time pressure,
- raising awareness among employees concerning risks in investment processes,
- departure from the selection of the investment contractor solely on the basis of the price criterion,
- reliable technical acceptances (takeovers),
- and others.

Risk analysis is a crucial element of designing, manufacturing or using technical devices. The provisions in certain standards concerning rtc systems and devices, especially those related to safety, impose an obligation to carry out risk analysis on designers and manufacturers. Pursuant to, [11], which demonstrates the system life cycle (e.g. rtc system), risk analysis is a necessary and essential element of the system life cycle. The risk analysis of an investment project must encompass the entire investment process, starting from the concept and ending up with implementation and use.

Currently, there are various risk analysis methods. The choice of the method is dependent upon the reference to the system for which the risk analysis is carried out, and also upon the significance and meaning of the investment, as well as upon the stage of implementation. In practice, there is a set of risk analysis methods. So far, the most frequent risk assessment methods have been the following:

- fault tree analysis,
- hazards and operating capability checks,
- human reliability analysis,
- Delphi method,
- Monte-Carlo simulation and other simulation-like methods,
- data review in retrospect,
- multi-criteria assessment.

As part of assessing the risk, it is possible to adopt qualitative analysis and/or quantitative analysis. It is definitely advisable to combine both methods. The quantitative analysis of risk allows the impact of risk to be assessed based on goals of the investment.

6. Conclusion

The modernization process, starting from tender documentation, through design documentation, obtaining CE certificates and ending with technical approval, is very complex. The use of objective methods which standardize precise problem solving, which support investments, will contribute to shortening the time for implementation of new automation systems and traffic control and signaling systems in railway transport. It is essential that risks are analyzed and awareness and liability among investment contractors are raised at each stage of the investment implementation.

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