PROFOUND ANALYSIS OF RAILWAY ACCIDENT CHARACTERISTICS AS A BASIS FOR AVOIDANCE OF CRISIS STATES OF TECHNICAL EXPLOITATION

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ABSTRACT

The continuous improvement of the knowledge related to technical exploitation and safety helps to increase the quality and efficiency of railway transport services. Regardless of the mode of transport (air, water or land) its main task is safe passengers and cargo transportation. The root causes of accidents are revealed through various approaches and research methods. Profound study and analysis of railway accident characteristics help to prevent the exploitation process from occurring of crisis situation.

Key words:
railway transport, accidents, crisis situations

ABSTRAKT

Neustále zlepšovanie znalostí týkajúcich sa techniky a bezpečnosti, prispieva k zvyšovaniu kvality a efektivity železničnej dopravy. Bez ohľadu na spôsob dopravy (ovzdušie, voda alebo pôda), hlavnou úlohou je bezpečnosť osobnej a nákladnej dopravy. Hlavné príčiny nehôd sú odhalené prostredníctvom rôznych prístupov a výskumných metód. Zásadné štúdie a analýzy charakteristík železničných nehôd pomôžu zabrániť procesu výskytu krízových situácií.

Key words:
železničná doprava, nehody, krízové situácie

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1 INTRODUCTION TO THE PROBLEM

Railway transport is an essential part of the transport system. It represents a complex of different technical railway means and organizational control system, intentionally combined for the implementation of the unified railway transport process, i.e. transportation of passengers and cargo. Increasing speed, safety and reliability in the management and organization of the transport process is an objective necessity of the European railway transport system. Achieving the maximum efficiency of the transport process can be done through its optimization at the corresponding technical equipment. The requirements and procedures for construction, maintenance, development and technical operation of railway infrastructure and basic rules for safe movement of trains and maneuvers are determined by the Railway Transport Act.

One of the key factors for the operation of railway transport is its reliability. It influences both traffic safety and economic efficiency. Therefore the aim is to explore the sites /locations/ with concentration of accidents on the railway network, their causes and consequences related to the efforts and measures for accident reduction. Assurance of safety and reliability of railway transport is a systemic problem, demanding formation of a clear purpose for the measures selected for improving safety. It is not clear where to focus the main effort, whether to improve infrastructure, spend resources to train participants in operational activities, for scientific research, to strengthen control or in a completely different direction [4]. World practice shows [3,9,10] that factors related to the human are actually the largest part of the occurence of accidents. On the other hand, it may be easier and more efficient to carry out engineering measures to resist the human weaknesses than it is to alter the behavior of the person.

Studies in the field of road transport [1,8] show that one of the most effective (from economic point of view) methods for accident reduction is connected with: discovery, detailed study and removal of black spots on the roads and the development of measures to improve safety. These mesures lead to a sharp decrease in accidents - sometimes even up to 80%. In the field of railway transport, the removal of hazardous areas can be expressed through decision of eliminating level crossings, closure or divergence on different levels or equipment by means of signaling, centralization and blocking.

2 BASIC CONCEPTS AND CHARACTERISTICS OF RAILWAY ACCIDENTS

Railway accidents in Bulgaria according to The Railway Transport Act are divided into the following categories: serious accidents, incidents and situations close to the incident.

An accident is an unwanted, unintended sudden event or a series of such events which have harmful consequences for the railway system. Accidents are: collisions, derailments, level-crossing accidents, accidents with people caused by rolling stock in motion, fires, etc.

Serious railway accidents are those that have occurred as a result of the derailment, ignition or impact of rolling stock, resulting in the death of at least one person or serious injuries to at least five people. *Major property/material damages* amount to aproximately 2 million euro.

Incident is every event associated with the train exploitation and affecting the safety of transport, which is not an accident, i.e. there are no dead, but there are up to five injured and damages up to 2 million euro. *Incidents in railway transport* are: broken rail, deformed railroad, passing a signal, damaged bogies of rolling stock in operation and failure in the signaling system in which the signal is less restrictive than required.

Situations, near misses are: damaged railway infrastructure or rolling stock, violations of standards and requirements for safety and transport processes that are not accidents or incidents.

Studies further discussing accident theories, investigation methods and simulation approaches in transport safety risk assessment, safety and security of railway vehicles, standards for safety and measures against terrorist attacks are [5, 6].

The fundamental accident characteristics mentioned there are: date, time and place of the accident; actions of officials before the accident; track conditions, safety equipment, catenary, rolling stock and other reflected in the documentation; causes of the accident; consequences of the accident (killed, wounded, damages, costs for recovery); proposals for the implementation of organizational, technical and other events in order to prevent accidents for the same reasons.

The criteria for change using quantitative measures: crossing should be converted into two levels if there are two or more significant damages annually. Significant damages are equivalent to 150 000 EUR according to Directive 2009/149/EC.

3 APPROACHES AND METHODS FOR RESEARCH AND ANALYSIS

This article discusses the most commonly used methods for reliability analysis [2] of complex technical devices applicable to the transport system which are: Reliability Block Diagram Analysis (frequently used for reliability analysis of complex systems); Hazard and operability study – HAZOP (a system is reliable when all its operating parameters are within normal limits); Failure Modes and Effects Analysis – FMEA (a systematic approach for research of failures); Fault Tree Analysis- FTA (a deductive approach for failures of the various building system components), Event Tree Analysis – ETA (an inductive approach, allowing identification and evaluation of all possible outcomes of the event in question).

In this article, using two of the above-mentioned methods for reliability analysis, are presented the results of studied accidents. The task is ensuring a high level of safety in the operation of railway crossings. Two level crossings in Bulgaria are examined with the objectives to compare their safety and to make a conclusion for taking measures for its improvement.

3.1 FAULT TREE ANALYSIS

Figure 1. presents an example of Fault Tree Analysis for a typical technical failure in railway transport of automatic crossing devices. Separate probabilities for the following events are calculated: T - lack of safety conditions of the level crossing; G1- presence of the train to the level crossing; G2 - presence of road vehicle on the level crossing; G3 - error in performing the protective functions of the automatic crossing devices; G4 - crossing does not close when approaching train; G5 - crossing opens prematurely before the train has passed; A - failure of track circuits, registering the approach of a train to the crossing; B - technical failure of the system transmitting information to the crossing devices for the approaching train to the crossing; C - technical failure of the barrier mechanism; D - dangerous failure of the scheme for tracking the actual passage.

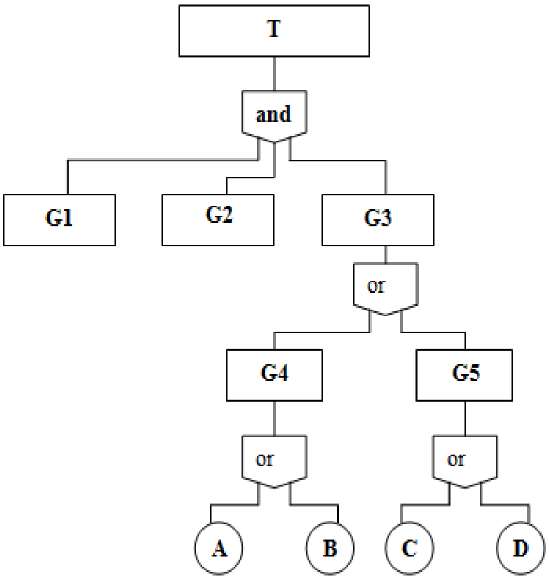

Figure 1 Fault Tree Analysis for a typical technical failure

To examine the level of safety of a level crossing (about the investigated hazard) it is necessary to have the probabilities of the individual events. The following two Bulgarian level crossing are examined: Galabnik – Delian at km. 68+884 and Blagoevgrad – Simitly at km. 125 +731.

The probability of occurrence of an event T, that characterizes the safety of the first level crossing is shown in (1).

The probability of occurrence of an event T (a hit between train and vehicle because of a technical failure of the automatic crossing devices) at the second level crossing is shown in (2).

$$PT1 = 0.00154 \quad (1)$$

$$PT2 = 0.00163 \quad (2)$$

$$PT1 < PT2 \quad (3)$$

3.2. EVENT TREE ANALYSIS

Figure 2 shows the structure of events and their consequences for road vehicles passing through the first level crossing. The structure of events and their consequences on road vehicles passing through the second level crossing are the same, but the results and input data different. For this level crossing the probability of a presence of a road vehicle on the level crossing is shown in (4), therefore probability P11 is shown in (5):

$$P12 = 0.13 \quad (4)$$

$$P11 = 0.87 \quad (5)$$

Probabilities P21, P22, P31, P32, P41, P42 are obtained by processing statistics. For the realization of the end event (C1, C2, C3 and C4) it was calculated:

$$C1 = 0.987 \quad (6)$$

$$C2 = 0.0104 \quad (7)$$

$$C3 = 0.0008 \quad (8)$$

$$C4 = 0.0018 \quad (9)$$

Each danger can be evaluated by the help of analysis of losses (analysis of the causes and consequences). The following probabilities are selected: P1 - for safe condition, P2 - for prevented hit, P3 - for train hitting road vehicle, P4 - for road vehicle hitting crossing devices. The results for the first level crossing are shown in formulas from (10) to (13), and for the second level crossing - in formulas from (14) to (17).

For the first level crossing:

$$P1 = 0.01152 \quad (10)$$

$$P2 = 0.000012 \quad (11)$$

$$P3 = 0.0000008 \quad (12)$$

$$P4 = 0.0000019 \quad (13)$$

For the second level crossing the results are:

$$P1 = 0.00161 \quad (14)$$

$$P2 = 0.0000169 \quad (15)$$

$$P3 = 0.0000013 \quad (16)$$

$$P11 = 0.0000029 \quad (17)$$

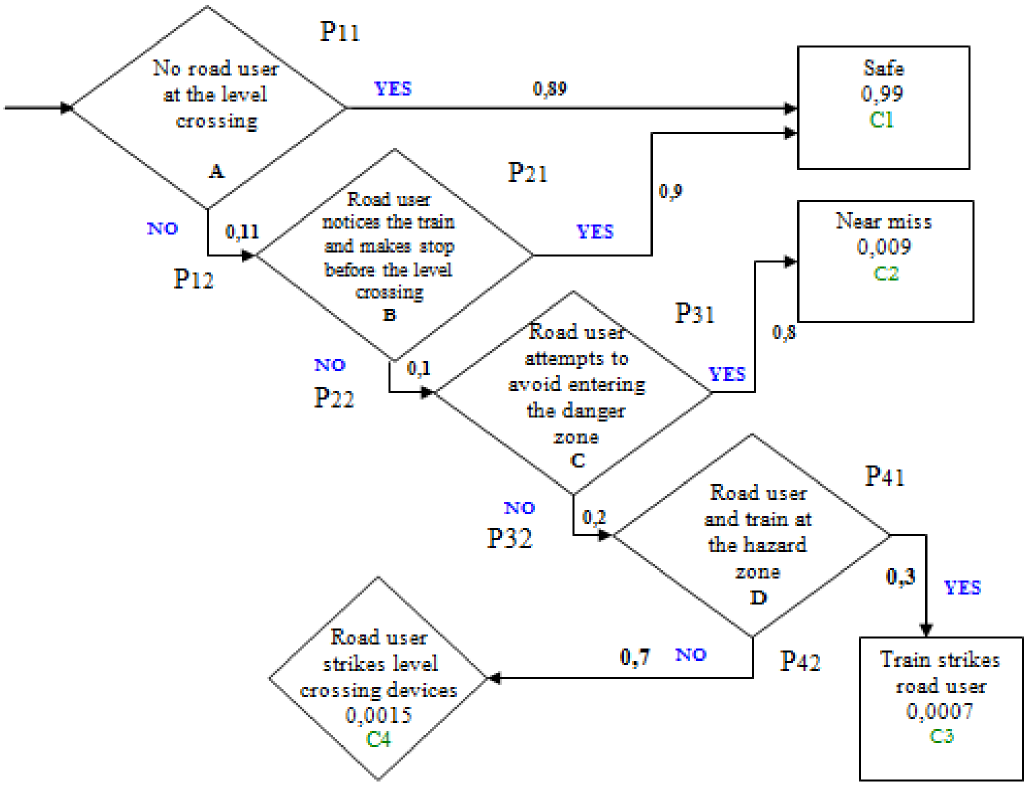

Figure 2 Event Tree Analysis for road vehicles passing through the first level crossing

The probability of a strike on the first level crossing /train hitting road vehicle (road user) and road vehicle hitting crossing devices/ is smaller, compared to the second level crossing, i.e. the first level crossing is safer.

4 CONCLUSION

The root causes of accidents found in the article show that the probability to get a crisis on the second level crossing is greater, although the fact that fewer trains pass there per day. The dangerous intersections on one level crossing should be reequiped or in the best case - directly removed/replaced by crossing on different levels, after profound study of accidents. The current rail legislation [7] prescribes inspections of the level crossing indicators, which is crucial for prevention and reduction of accidents in railway transport.

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Článok recenzovali dvaja nezávislí recenzenti.