Polish Railway Safety Performance in 2016

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In comparison, railways are the safest mode of land transport, not only regarding pure safety performance indicators but also considering external costs to society and to a member state.
As for Polish railways, the year 2016 was the safest since 2008 even despite the growth of the railway market.
There are still elements that need to be taken care of, such as continuous improvement of safety culture so that there can be a consistency in safety statistics, and improvement of total safety performance. The other key aspect is the analysis of human factor with the involvement of professionals in the area of human performance since it seems that current activities are insufficient.
Authors would like to summarise this short article regarding railway safety performance by saying that undoubtedly, railways are constantly the mass transport mode to choose regarding the safety of travel.

Keywords: safety, safety performance, common safety indicators, accident investigation, Poland, railways.

1. PROLOGUE

Safety has always been the key feature of transport, especially regarding passenger services and transport of dangerous goods. It is one of the most significant values in railway transport due to its very structured approach and highly organized manner. Railway transports large amount of goods which inflicts operating with heavy vehicles where a slight error can cause catastrophic consequences. The second most important factor in making railways such a safe means of transport is the human factor – the devotion to railways of people who are involved in it, and high level of competencies required for nearly every post which is involved in operational services. In summary, available historical data on fatal railway accidents shows a solid gradual improvement in railway safety over the past three decades, which has slowed down since the late 1990s. This "softening" of the trend is observable when analyzing both absolute and relative figures of fatal train collisions and derailments in Europe. [1]

Due to this aspect, while organizing railway transport there is a high demand for specialized engineers who can aid the safety matters of railway transport not only on the operational level but mainly on the management level. Proper data analysis and giving precise conclusions and safety targets are at stake. Thus, there are a lot of courses dedicated to safety engineering, based on experiences from other branches of technical science and transport modes. They implement such elements of the art like: proactive safety management, risk analysis, accident investigations etc. These courses are provided at different levels of individuals education, from technical college-like level, through dedicated specializations during bachelor's and master's studies, up to postgraduate studies and doctorate theses. It seems that the role of well-trained safety engineers will greatly increase in the railway sectors in the following years.

As it is well described in aviation literature, a proper safety-related data analysis is crucial for improving safety. Extracting knowledge from the mistakes made is the minimum requirement for preventing them in future – a cornerstone of safety culture. As one can see from the higher number of

railway events[1] for analysis last year it seems that also railway companies see the full potential in this area and the grey area of reporting seems to be decreasing.

As it was stated at the beginning, there are some differences between transport modes:

- Level of organization – in general companies in maritime, aviation and railway are far more structurally organized and larger per company then in road transport, the other aspect is that they usually derive from national operators where road transport seems to be more open and competitive,
- Level of administratory regulation – there are regulatory bodies in every industry but mostly one can find them outside of road transport, from the aspect of access to the market (licence and safety certificate in railways for the level of company, authorisation of placing in service for technical assets, and competency management for safety-related posts etc.). Other aspects of regulatory supervision and aid of transport are investigation bodies, where throughout Europe one can find them outside of road transport, mainly in aviation and railways,
- A natural approach to internal regulation form organizational culture approach from companies – aviation is built on procedures for nearly every aspect of transport, railways also have a strong internal regulations backbone for operation, lately (from around 2004) also going into the direction of management systems for safety and maintenance. When on the other hand, in road transport generally each company sets out their own individual rules,
- Access for non-professional operators to the transport infrastructure – road transport is the only one with open access for "amateur" operators (drivers) to the same infrastructure that professionals operate, with slight resemblance in maritime (but significant differences in size of vessels). In aviation small airplanes, usually operated by nonprofessional pilots, can operate to a certain flight level and in railways there are only professional drivers.

All of these differences and far more, like the level of the safety culture of transport users, will eventually have its influence on safety performance.

2. SAFETY PERFORMANCE REGARDING DIFFERENT TRANSPORT MODES

The European Union's Agency for Railways (EUAR or the Agency) started to compare safety

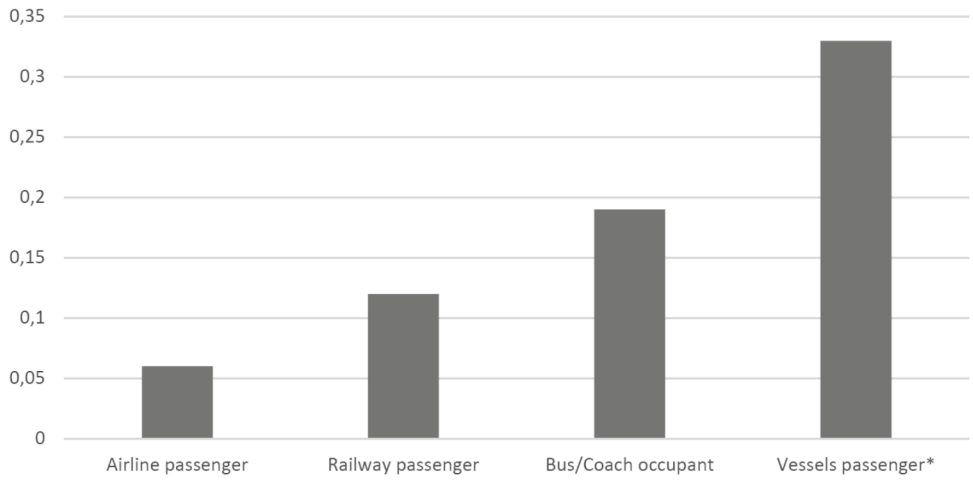

Fig. 1. Fatalities per billion passenger kilometres for different modes of transport in the EU (2010-2014)[2] [1].

[1] Railway events in this article are understood as serious accidents, accidents, and incidents under the Polish national law.

[2] Source of data: Passenger kilometre data taken from the EU transport in figures (Statistical Pocketbook 2014, DG MOVE 2014, European Commission). Airline passenger fatalities over EU-28 territory by any operators (Annual Safety Review 2014, EASA), Bus/occupant fatalities estimated from available data in CARE database (European Commission), Vessels passenger fatalities as reported by EU and EFTA MS as per Directive 2009/18/EC for years 2011-2014 (EMSA, 2016).

performance between different transport modes a couple of years ago. The most up-to-date comparisons are shown in Figure1[1]. As it can be observed, aviation is still the safest mode of transport regarding the number of fatalities and travel distance, while the railways remain the safest land transport mode.

In the following analysis, the authors focused on road and railway transports as they are the most common and very accessible for passengers, especially regarding distances up to 500 km. General safety performance values for each transport modes are given in Table 1.

Table 2 Comparison of safety performance in land transport (nr of fatalities and operational work)[3].

Accident measure for **freight transport**	Accident measure for **passenger transport**	*year* ***2016***
0,010	0,157	***Road transport***
0,006	0,015	***Railways***

Another interesting field of comparison is a number of fatalities and distance covered by road and railway vehicles. Figure 2 shows the average of fatalities regarding operational work in road transport. Poland's system is unfortunately the last one, with nearly 18 people killed on roads per one billion vehicle-km.

Table 1. General safety performance data for road transport and railways.

Transport mode (data for 2016)	**Number of accidents / incidents**	**Number of fatalities / seriously injured / injured**	**Economic cost (2014 & 2015)**
Road transport	33,664 / 406,622	3,026 /12,109/40,766	PLN 48.2 bln - 2015[8]
Railways	581 / 837	169 / 94 / -	EUR 153.9 mln -2014

One can clearly see that the difference in data is staggering and favouring railways, even having in mind the difference in a number of million passenger-km done by each mode (in 2016 [9] - 292 for railways and 390 for road transport). Regarding land transport in Poland, the authors compared the number of fatalities with the operational work in railway and in road transport, the comparison is shown in Table 2.

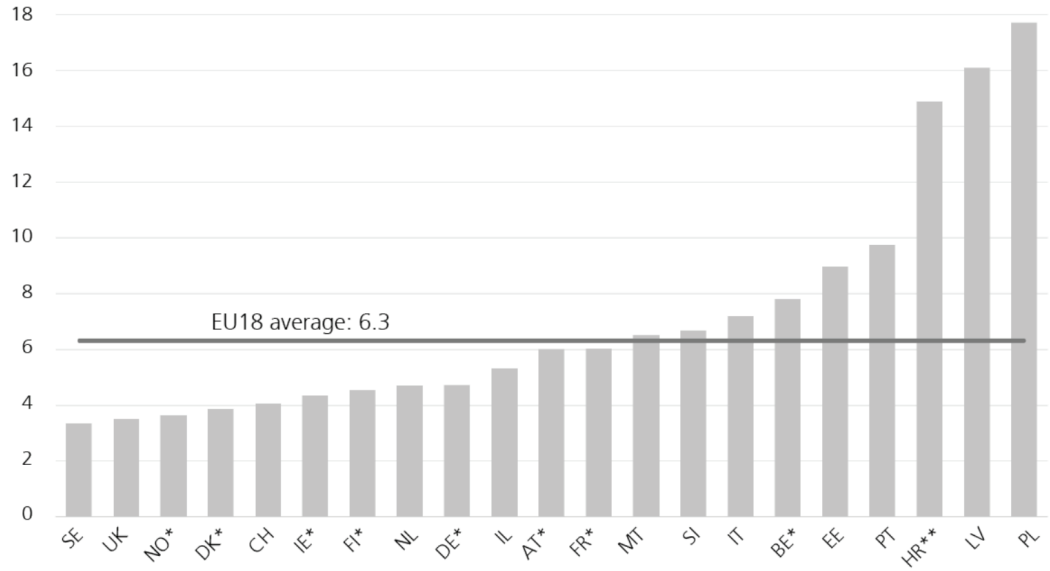

Fig. 2. Road deaths per billion vehicle-km[4] [6].

Figure 3 shows the appropriate measure for railways and one can clearly see that there is a

[3] Measure was calculated on data from [2][3] and data from Central Statistical Office of Poland (www.stat.gov.pl)

[4] Average for the latest three years for which both the road deaths and the estimated data on distance travelled are available. 2013-2015 (HR, LV, SE, CH), 2012-2014 (AT, SE, DK, FI, FR, IE, NL, PT, UK, IL, NO), 2011-2013 (BE, PL), 2014-2015 (MT). *Provisional figures for road deaths in 2015. **Road deaths per billion vehicle-km travelled by cars only.

significant reduction in number of fatalities per train-km. These can be treated as equal to vehicle-km, despite the fact that trains usually consist of multiple vehicles. Even at the EU level, there is a nearly 21-time reduction in the average number of fatalities. Also, the same applies to Poland – 15 times higher for road transport.

3. RAILWAY SAFETY PERFORMANCE IN POLAND FOR 2016

This paragraph is based on the most relevant data for Polish railway market which are published in the latest report of Polish national safety authority – the President of Office of Rail Transport - [3]. First of all, the authors focused on a primary measure for safety performance which is the number of accidents[5] related to operational work for the whole railway market.

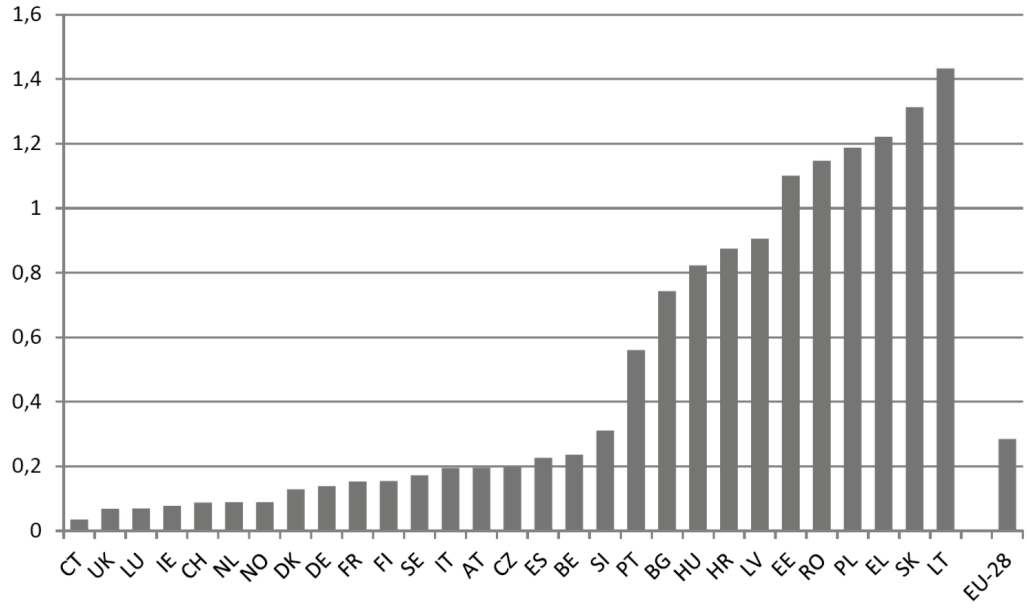

Fig. 3. Railway fatalities per million train-km (2010-2014) [1].

Other interesting aspects of safety performance are external costs of transport which were studied by professor A. Merkisz-Guranowska team and described in [7]. The summary is given in Table 3, and it also clearly states that rail transport is the best choice for mass land transportation.

Table 3. The comparison of external costs of transport modes [7].

[euro/1000 tkm]	Road transport	Railways	Inland shipping	Short sea shipping
Accidents	5.44	1.46	0	0
Noise level	2.14	3.45	0	0
Pollution emission	7.85	3.80	3	2
Greenhouse gas emissions	0.79	0.50	irrelevant	irrelevant
Infrastructure	2.45	2.90	1	< 1
Congestion costs	5.45	0.24	irrelevant	irrelevant
Summary:	**24.12**	**12.35**	around **4.0**	around **3.0**

2016 was another year in which UTK recorded a reduction in accidents, despite a 7% increase in operational work, which resulted in reduction of the accidents measure to the lowest level since 2008.

Another important aspect of safety performance are Common Safety Targets calculated in six different categories. These values are then compared to National Reference Values which are also calculated according to the European regulation for each member state. These evaluated NRV levels for Poland in respect of CST values in years 2013-2016 are shown below in Figure 5. As one can see there is a general decrement in all CST values, which is a desirable tendency, unfortunately, risk towards level crossing users, unauthorized persons, and societal risk are still at quite a high level (around 80%, 44% and 48%).

[5]Accident is considered a railway event which results in negative measurable consequences regarding people, environment or generally expressed in cost (above 3,000 euro).

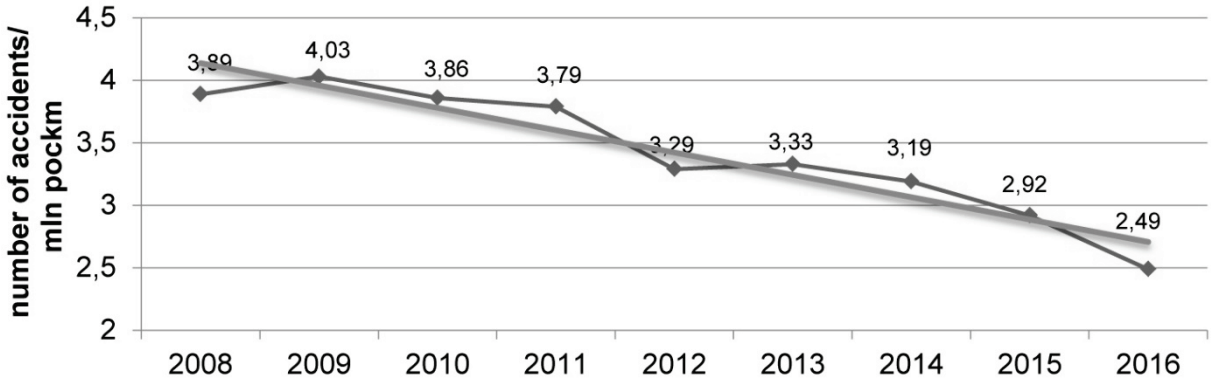

Fig. 4. Value of accidents measure [3].

These areas still require being addressed by railway actors in their safety management systems (SMS) according to their risk assessment.

the President of UTK began to implement safety culture policy and their SMS, and gradually began to see the benefit of conducting the analysis of all

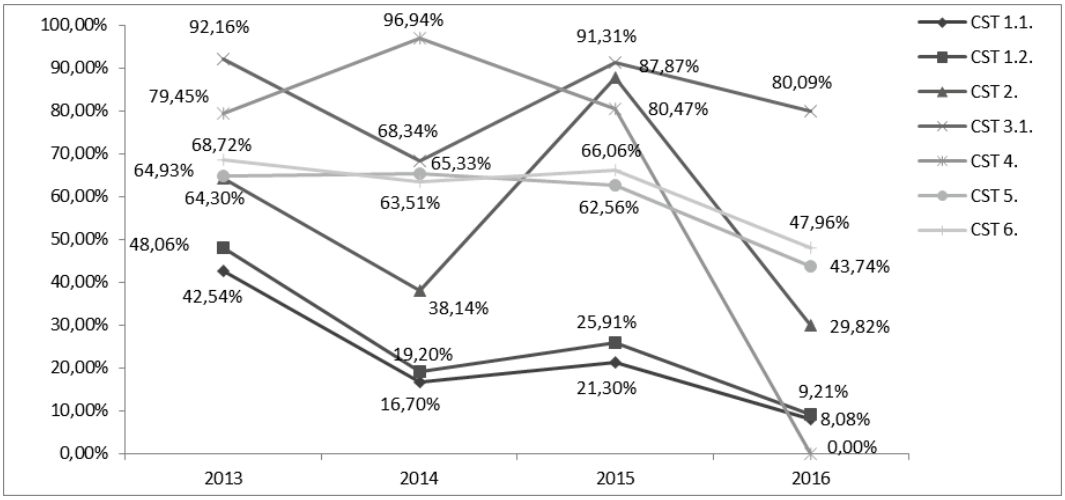

Fig. 5. Common Safety Targets achieved for Poland in 2013-2016 [3].

As for specific values that were calculated in 2016, they are shown in Table 4. As it has been said before, CST 3.1, 5 and 6 as they have quite high relative values, still need to be taken care of.

Another positive aspect that was identified in 2016 is the regular growth in a number of incidents per year since 2013. Of course, it is intended to have the number of railway events as low as possible, unfortunately in the past a significant number of events that should have been qualified as incidents were hidden in internal categories of railway undertakings and infrastructure managers. Due to consistent "zero tolerance" policy of the President of Office of Rail Transport since 2013 and putting emphasis on effective implementation of Safety Management Systems railway, actors began to understand that there is no point in hiding incidents, even if there were less investigation and analysis to be done. The companies encouraged by unwanted events in their systems. Finally, in 2016 the number of incidents exceeded the number of accidents, which seems to be a natural course of things regarding their significance – fewest events with highest consequences, and most events with least consequences. As companies need to investigate all of those accidents and incidents, the most likely outcome is a continuous improvement in safety, as one of the main goals of each SMS is to prevent accidents and incidents from happening.

Table 4. Achieved CST values in 2016 [3].

Common Safety Targets (CST)		NRV for Poland	CST value for Poland	NRV level
NRV risk to passengers (x 10^{-9}) 2016				
CST 1.1.	Fatalities and weighted serious injuries (FWSI) among passengers per billion train kilometres of passenger trains	116,1	9,376	8,08%
CST 1.2.	Fatalities and weighted serious injuries (FWSI) among passengers per billion passenger kilometres	0,849	0,078	9,21%
NRV risk to employees (x 10^{-9})				
CST 2.	Fatalities and weighted serious injuries (FWSI) among employees per billion train kilometres	17,2	5,130	29,82%
NRV risk to level crossing users (x 10^{-9})				
CST 3.1.	Fatalities and weighted serious injuries (FWSI) among level crossing users per billion train kilometres	277	221,852	80,09%
CST 3.2.	Fatalities and weighted serious injuries (FWSI) among passengers per billion passenger kilometres (km) multiplied by the number of level crossings	n.a.	-	-
NRV risk to others (x 10^{-9})				
CST 4.	Fatalities and seriously injured (FWSI) among other people in one billion train kilometres	11,6	0,000	0,00%
NRV risk to unauthorized persons (x 10^{-9})				
CST 5.	Fatalities and seriously injured (FWSI) among unauthorized persons in one billion train kilometres	1210	529,197	43,74%
NRV societal risk (x 10^{-9})				
CST 6.	Fatalities and seriously injured (FWSI) among all people per billion train kilometres	1590	762,591	47,96%

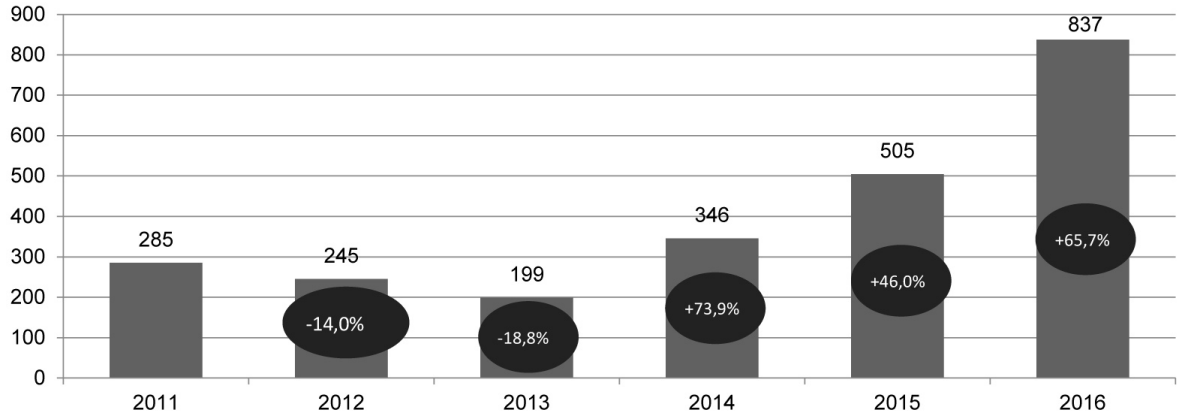

Fig. 6. Number of incidents on railway lines in years 2011-2016 [3].

There were also other activities of the President of UTK that influenced safety performance i.e. supervision activities. The way that those activities were performed was in 2013 shifted towards a systematic approach with stronger enforcement actions taken afterward. The other element was a change in approach towards efficiency so that each year there were more activities conducted. In 2016 there was a change in legislation and the President of UTK became responsible for supervision of railway commission (which is responsible for the investigation of every accident and incident). This resulted in additional growth, due to the new scope of activities.

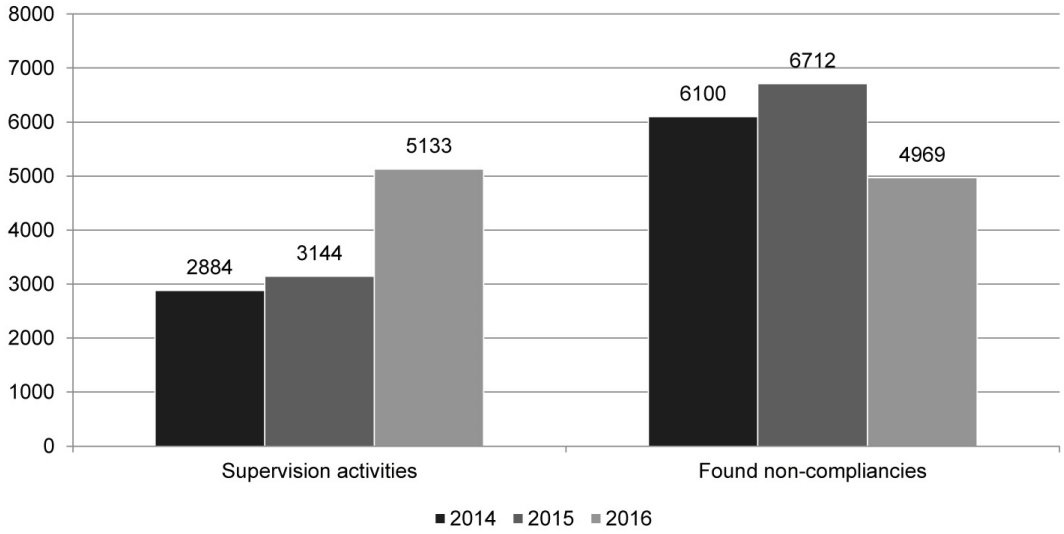

Fig. 7. General data regarding supervision activities in years 2014-2016 [3].

The other outcome of consequent supervision was the decrease in a number of found non-compliances. It seems that the railway companies began to understand the point of having their own Safety Management Systems so that they took action and did not wait for a control of a supervision body.

There are also general studies conducted regarding railways safety, one of them focused on the decomposition of primary causes of accidents and incidents. The study was started by Eng. D.R. Wachnik during his studies and then was continued by EngD K. Chruzik. The latest data come from 2012 and are described in [4] and shown in Figure 8. Unfortunately, more than two-thirds of railway events have their origin outside of the railway system – it concerns "unauthorized persons on railway tracks" and "level crossing users" which in most cases do not comply with legal restrictions and eventually not only break the law but also cause damage to the railway system.

As these two subjects i.e. unauthorized persons and level crossing users' behaviour are the remaining safety issues, also the President of UTK addresses these subjects with supervision activities. These activities were described in detail in [5]. The main approach is to point out any illegal crossing to the infrastructure managers, provide technical controls on level crossing but mostly act on soft aspects like education of the youth during campaign "Railway ABC" which is dedicated towards pre-schools in places with the highest number of accidents on railway crossings.

Another aspect of the above mentioned activities is encouraging infrastructure managers to upgrade their level crossing towards a B category (automatic system with barriers) which has the lowest safety measure, except man-operated A category. It may seem that A category is the way to go, but one must keep in mind that this measure

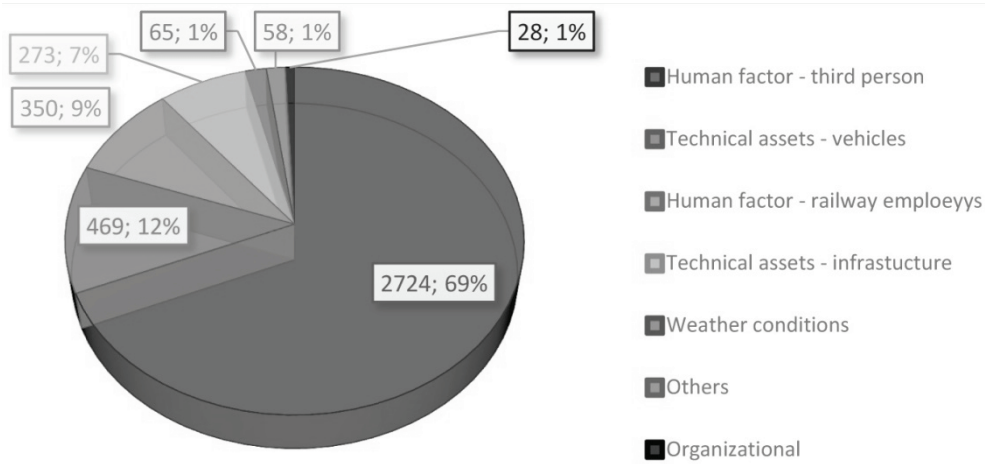

Fig. 8. Structure of the railway events (number of events, the percentage) due to their primary reason for covering the period 2009-2012 [4].

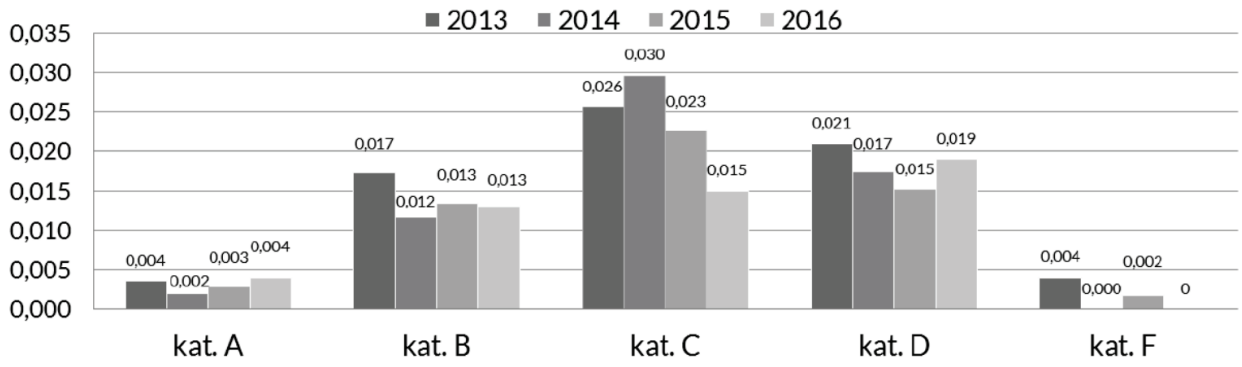

Fig. 9. Accidents measure on railway crossings in years 2013-2016 [5].

strongly relies on the number of level crossings, and having in mind the cost of operation of A – level crossing and the possible influence of human factor, the B – level crossing seems to be the optimal choice.

The last-mentioned aspect is the impact of a human factor on railway events, it is most significant regarding SPADs[6]. Figure 10 shows the number of SPAD, regardless their qualification in the last 4 years. There has been a large increase in the number of events since 2015, which continued in 2017.

Figure 11 shows the possible and real outcome of a SPAD, in this specific case a train driver of a freight train missed a STOP sign and entered an occupied track on which the passenger train was already running. It was impossible to avoid the collision and the passenger train was nearly entirely derailed – fortunately, no one was killed or seriously injured. It was one of a couple of similar events in 2017 and it clearly shows that even the slightest mistake regarding train operation can result in a catastrophe. This subject needs to be properly analysed as for now it seems that the corrective measures that are applied are ineffective. It is possible that a proper analysis of human factor involvement is a necessity.

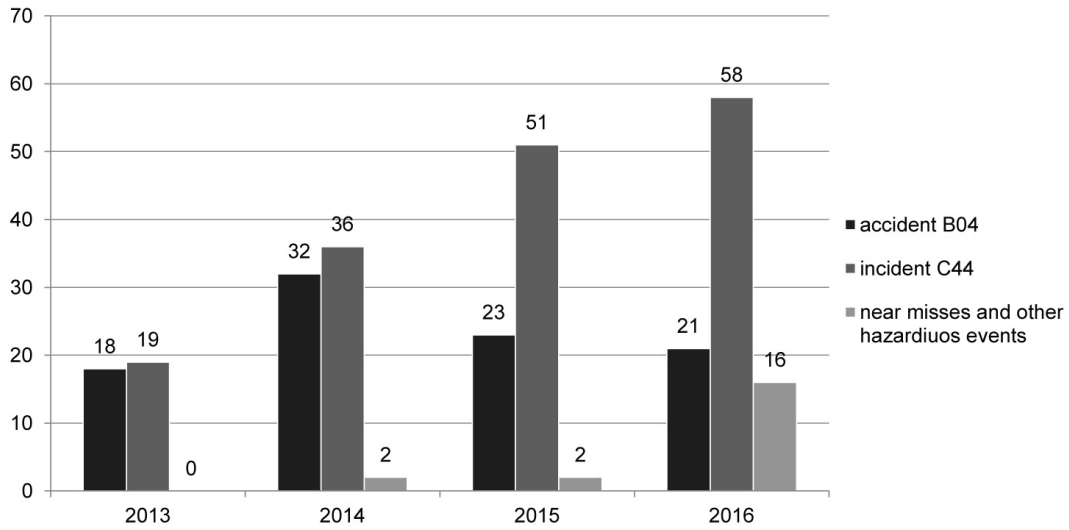

Fig. 10. Number of SPAD's in years 2013-2016 [3].

[6]Signal Passed at Danger (SPAD) means any occasion when any part of a train proceeds beyond its authorized movement and travels beyond the danger point. Danger point is a point at which the train will be in a danger of an accident (collision, level-crossing accident, accident to a person caused by rolling stock in motion or derailment). It is usually defined in the specifications of the Train Protection System.

Fig. 11. Example of outcome after a SPAD[10].

4. SUMMARY

In comparison, railways are the safest mode of land transport, not only regarding pure safety performance indicators but also considering external costs to society and to a member state.

As for Polish railways, the year 2016 was the safest since 2008 even despite the growth of the railway market.

There are still elements that need to be taken care of, such as continuous improvement of safety culture so that there can be a consistency in safety statistics and improvement of total safety performance. Another significant element is the analysis of human factor with the involvement of professionals in the area of human performance, since it seems that current corrective activities are insufficient.

Authors would like to summarise this short article concerning railway safety performance by saying that undoubtedly railways are the mass transport mode to choose, as far as the safety of travel is concerned.

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