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Table of contents

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Optimization of Fuel Costs Using the Information System

Dušan Halaj[1]

[1] University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, Žilina, 010 01, Slovakia

Abstract The paper deals with optimizing fuel consumption through the use of information system in road freight transport. The aim is to calculate and compare the costs for an operation with the information system as well as without it.

Keywords Information System, Semi-Trailer, Fuel Costs

JEL L91 - Transportation: General

1. Introduction

The road freight transport market can be characterized as a market with a high degree of competition. On this type of market, only the carriers that efficiently manage available resources have a chance to succeed. This means that they are able to effectively operate their fleet (vehicle fleet) and optimize their costs. Carriers try to minimize their operating costs to the lowest level while keeping a quality of services provided. Various cost items can be optimized in a transport company but attention should be paid mainly to the fuel costs which are the highest cost item in road freight transport. Fuel costs account for about 40% of the total costs. Therefore, it is necessary to monitor and optimize this cost item. Fuel costs can be optimized in different ways:

- fuel consumption reduction through better driving techniques,
- refuelling outside of highways,
- refuelling at petrol stations and in countries where the fuel prices are lower,
- using vehicles with lower fuel consumption on longer distances.

2. Functions and price of information system which is necessary for controlling and monitoring fuel consumption

The factors such as a poor technical condition of the vehicle and a bad driving technique can have an impact on increasing fuel consumption. In most cases, a poor driving technique is the most common negative factor. The carriers can monitor the fuel consumption of individual vehicles as well as a driver's activity during transportation using functions of appropriate information systems. Introducing the information system, the carriers are able to identify which of drivers and vehicles demonstrates over-consumption due to a bad driving technique. The price for such functions of the information system is approximately 25 €/month and the carriers do not need to install any additional hardware in vehicles. Purchasing the information system, the carriers obtain functions as follows:

- tracking and tracing – it is used to determine the vehicle position in real time,
- processing the working time of a driver,
- data processing of driving, fuel consumption and driver's identity,
- integrating all the data to a centre.

3. Data processing of driving, fuel consumption and driver's identity

Data processing of driving, fuel consumption and a driver's identity is a service offering information about fuel consumption for a given vehicle during particular carriage, average consumption for the entire journey or its individual sections and overall average fuel consumption of the vehicle. Furthermore, the service is used for transmission of important information about riding, a driver, and vehicle. The output may be a graph with a percentage representation of consumption.

The output can also be a report about a vehicle performance for a certain time period. The dispatcher can monitor:

- **report about fuel consumption** where the fuel consumption for the total time of the vehicle operation is recorded; there is also shown how much fuel was consumed during the vehicle running at idle,
- **performance** indicating the average fuel consumption in liters per 100 km, average fuel consumption for a journey, average speed, total distance travel, average axle load, and average number of stops per 100 km (the more stops, the higher fuel consumption),
- **driver's behaviour** where the driver's impact on vehicle fuel consumption is evaluated. The output is the per-

centage of the total time, when the driver went faster, which consumption is above average; how much time the driver travelled at high engine speed; how many times the driver had to brake sharply; how many hours from the total driving time the driver went at idle, how many kilometres the driver travelled using cruise control; and how many hours the driver was driving economically.

Based on above mentioned, the carriers have information about individual drivers with bad driving techniques and thus they can alert a particular driver to the areas where he makes mistakes. The mentioned information may also help drivers whose fuel consumption is at the required standardized level to improve their driving technique and skills. In this way, the fuel consumption can be reduced by 5 %.

4. Cost comparison before and after an introduction of the information system

The costs invested by carriers into the information system should not be higher than savings achieved by the carriers when using the information system. In addition to reducing the consumption, the carriers can also obtain further functions by purchasing the information system. Based on average costs shown in Table 1, it is possible to calculate cost savings when using the information system in €/km and /year; the method used is the calculation with classification of costs on fixed and variable costs.

Table 1 – Average costs €/year a data for the articulated vehicle

Fuel costs – 42 500
Oil costs – 800
Tires costs – 2 500
Maintenance, repair and treatment (M, R and T) – 5 950
Wages with levies – 14 000
Travel compensation (TC) – 7 000
Heating vehicle costs (HV) – 495
Coefficient of drives utilization – 0,80
Other direct costs (ODC) – 5 200
Depreciation of vehicle – 13 500
Overhead – 7 000
Toll – 12 000
Driving performance - 110 000 km
Time of operation – 3 000 h/year
Technical speed – 55 km/h

The following tables (Tab.2, Tab. 3, and Tab.4) contain the calculated costs in €/km and €/h of the operational downtime (idle time) in situations before and after the introduction of the information system. Using the information system, it was possible to reduce fuel costs by 5 % or 0.5 %; however, there is a need for an increase in costs due to the monthly fee for the information system.

Table 2, 3, 4 – Comparison of charges during the utilization of individual information systems

	Costs	*Without IS*	
Item	**€/year**	**C_{km}(€/km)**	**C_h(€/h)**
Fuel	**42500**	**0.3864**	-
Oil	800	0.0073	-
Tires	2450	0.0223	-
M,R and T	5950	0.0541	-
Toll	12000	0.1091	-
Wages	14000	0.0848	4.67
TC	7000	0.0424	2.33
Levies	13500	0.0818	4.5
ODC	5200	0.0315	1.73
HV	495	0.003	0.17
Overhead	7000	0.0424	2.33
Fee		-	-
Total		***1.0814***	***15.73***

	Costs	*IS and consumption -5%*	
Item	**€/year**	**C_{km}(€/km)**	**C_h(€/h)**
Fuel	**40375**	**0.367**	-
Oil	800	0.0073	-
Tires	2450	0.0223	-
M,R and T	5950	0.0541	-
Toll	12000	0.1091	-
Wages	14000	0.0848	4.67
TC	7000	0.0424	2.33
Levies	13500	0.0818	4.5
ODC	5200	0.0315	1.73
HV	495	0.003	0.17
Overhead	7000	0.0424	2.33
Fee	**300**	**0.0018**	**0.1**
Total		***1.0595***	***15.83***
Cost savings by reducing consumption by 5%			***2406 €/year***

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	Costs	*Consumption -0.5%*	
Item	**€/year**	**C_{km}(€/km)**	**C_h(€/h)**
Fuel	**42287.5**	**0.3844**	-
Oil	800	0.0073	-
Tires	2450	0.0223	-
M,R and T	5950	0.0541	-
Toll	12000	0.1091	-
Wages	14000	0.0848	4.67
TC	7000	0.0424	2.33
Levies	13500	0.0818	4.5
ODC	5200	0.0315	1.73
HV	495	0.003	0.17
Overhead	7000	0.0424	2.33
Fee	**300**	**0.0018**	**0.1**
Total		***1.0813***	***15.83***

5. Conclusions

Based on the calculated costs it can be stated that if carriers reduce fuel consumption on average by 5 % per each vehicle, the savings achieved will be significantly higher than the costs associated with the use of the information system. The carriers would achieve costs of 1.0814€/km without the information system and fuel cost reduction. On the other hand, the carriers can reduced their costs by 1.0595 €/km when using the information system. This represents savings of 2 406 €/year. The following data shows that if carriers save 0.5 % of fuel costs, the costs on the information system will be approximately compensated by savings achieved from the fuel consumption reduction. Moreover, by purchasing the information system, the carriers can obtain other functions that might help in business. If the carriers have different inputs, the values will vary.

The following Figure 1 shows the cost savings in €/km when using the information system and reducing fuel consumption by 5 % and 0.5 % per each vehicle.

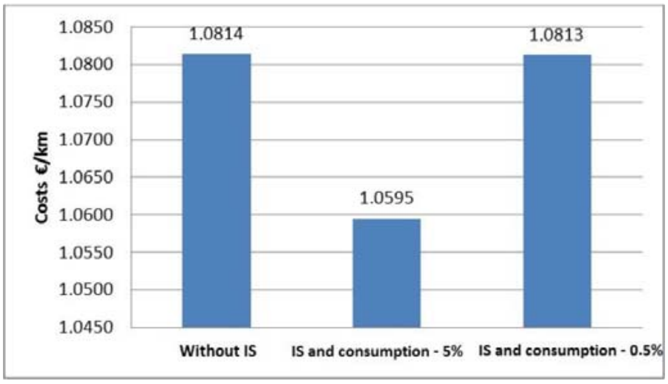

Figure 1. – Comparison of costs in €/km within the fuel consumption reduction

The following Figure 2 shows the cost savings in €/year when using the information system and reducing fuel consumption by 5 % per each vehicle.

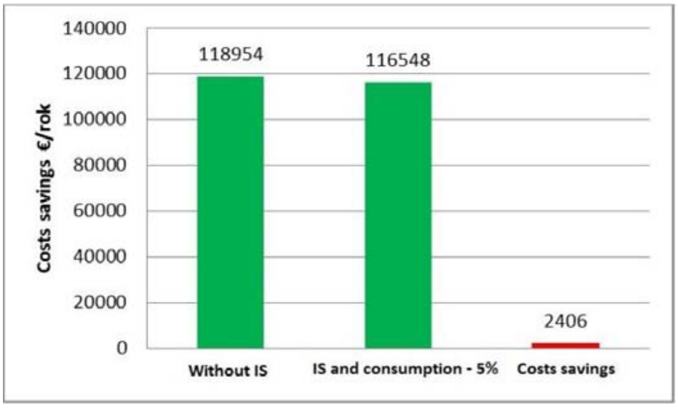

Figure 2. – Comparison of costs in €/year within the fuel consumption reduction

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The measurement of contact surface of dunnage bag used for cargo securing in different gaps between cargo

Juraj Jagelčák, Ján Vrábel, Matej Pauliak[1]

[1]University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport
jagelcak@fpedas.uniza.sk, vrabel@fpedas.uniza.sk

Abstract This article provides comparison between the measured values of dunnage bag restraining forces and calculated values of restraining forces according to the draft version of Guidelines for Packing of Cargo Transport Units (CTU Code) for the dunnage bag of dimensions 60x120 cm and maximum filling pressure 0.2 bar.

Keywords dunnage bags, CTU Code, contact surface, cargo securing

JEL L91 - Transportation: General

1. Introduction

Accelerations during transport cause the movement of a cargo, especially sliding or tilting. When dunnage bags are used as cargo securing equipment they should be able to secure cargo against sliding and tilting for different accelerations occurred during transport. Dunnage bags are used to fill gaps between cargo units to avoid displacement of units during transport. Dunnage bags are an effective form of cargo protection against load displacement and subsequent damage. There are different kinds of dunnage bags on the market (material, size, strength, filling equipment etc.).

Dunnage bags are placed into the gaps among the cargo units. After that they are inflated and cargo is fixed. Following rules must be expected. The first thing is to choose the correct type of the dunnage bag (dimensions, strength or the blocking capacity). The next very important condition is that the dunnage bag should not be over the edge of the cargo (the size of dunnage bag should not be higher than the size of a contact surface of a cargo). Dunnage bags must not be in a direct contact with sharp edges which can damage the dunnage bag. Because of that, e.g. paperboard can be placed between the cargo and the dunnage bag.

Another very important condition is that they should not touch the floor and can't be placed between the last cargo section and container or trailer doors. It should also be determined whether the dunnage bag is suitable for the particular gap. Required size and strength of the dunnage bag is determined by the size and weight of the cargo, gap where the dunnage bag is placed and accelerations which can occur during transport. With respect to the strength of the dunnage bag the blocking capacity of the dunnage bag must be higher than the forces acting on the dunnage bag by secured cargo.

2. Forces acting on cargo during transport

For all kinds of transport maximum design values of inertia forces are settled for longitudinal, transverse and vertical axes. These values are also used in theoretical calculations of force acting on the dunnage bag during transport. The Association of American Railroads [6] distinguishes between dunnage bags for transverse securing of cargo and longitudinal securing of cargo. Dunnage bags used for cargo securing in longitudinal direction must be stronger than dunnage bags used for cargo securing in transverse direction.

Table 1. Design acceleration coefficients for cargo securing

Transport	Forwards		Backwards		Sideways	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
Road	0.8	1	0.5	1	0.5/0.6	1/1
Rail	4/1	1/1	4/1	1/1	0.5/0.5	0.7/1
Sea A	0.3	0.5	0.3	0.5	0.5	1
Sea B	0.4	0.3	0.4	0.3	0.7	1
Sea C	0.4	0.2	0.4	0,2	0.8	1

Source: [2]

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3. Theoretical calculations for determining the dunnage bag suitability

Firstly it is necessary to know if the dunnage bag can be used in the particular gap. Therefore, we need to determine the maximum gap for which a particular dunnage bag can be applied.

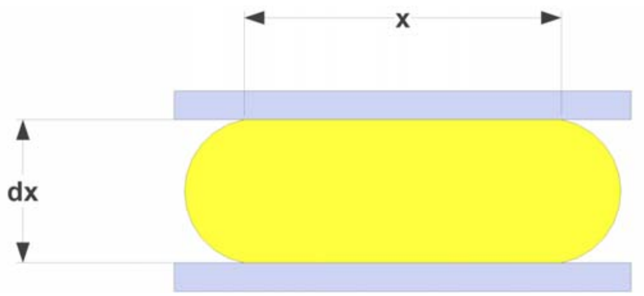

Figure 1. Contact distance x of dunnage bag in gap dx

Source: Authors

Maximum gap in which the dunnage bag can be placed depends on chosen ratio between the contact transverse distance *x* and breadth of dunnage bag *b* in non-inflated state as follows:

$$d_x = 2 \cdot \mathrm{b} \cdot \frac{1 - \frac{x}{b}}{\pi}$$

Following figure shows different maximum gap d_x for different ratios *x/b* and different breadth of dunnage bags.

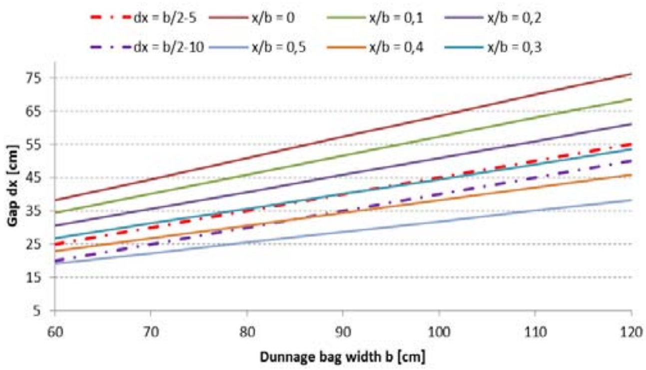

Figure 2. Maximum gap distance dx of dunnage bags of different breadths

Source: Authors

When the calculation of maximum gap for dunnage bag is $d_x = b/2\text{-}5$ [cm], it gives the results close to $x/b = 0.3$, so about 30 % of breadth of dunnage bag is in contact with a cargo. When the calculation of maximum gap for dunnage bag is $d_x = b/2\text{-}10$ [cm], it gives the results close to $x/b = 0.4$, so about 40 % of breadth of dunnage bag is in contact with a cargo.

The force which the dunnage bag is able to secure depends on the contact area of the dunnage bag which the cargo is resting against and the maximum allowable pressure in the dunnage bag. The blocking capacity of the dunnage bag is calculated according to the CTU Code [1] as follows:

$$F_{DB} = A \cdot 1000 \cdot g \cdot P_b \cdot SF\ [daN]$$

F_{DB} – force that the dunnage bag is able to secure without exceeding the maximum allowable pressure [daN]
A – contact area between the dunnage bag and the cargo [m^2],
P_b – bursting pressure of the dunnage bag [bar],
SF – safety factor
0.75 for single use dunnage bags,
0.5 for reusable dunnage bags.

For the calculation of the maximum permissible force it is necessary to know contact surface A, which is expressed according to the CTU Code [1] as follows:

$$A = \left(b - \pi \cdot \frac{d}{2}\right) \cdot \left(h - \pi \cdot \frac{d}{2}\right)$$

b – width of the dunnage bag [m],
h – height of the dunnage bag [m],
A – contact area between the dunnage bag and the cargo [m2]
d_x – gap between packages [m],
π – 3.14159

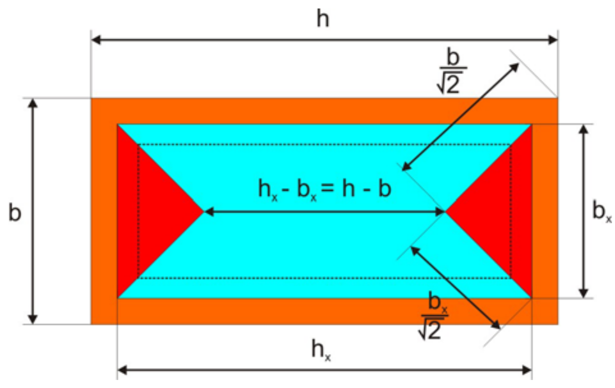

Figure 3. Contact surface of dunnage bag in gap dx calculated according to the CTU Code

Source: Authors

4. Measurement and evaluation of measured values

Testing gap is settled at the beginning of each measurement. Testing construction used to test the dunnage bag is in Fig. 4. The upper plate is connected with four threaded bars connected with four load cells at the bottom.

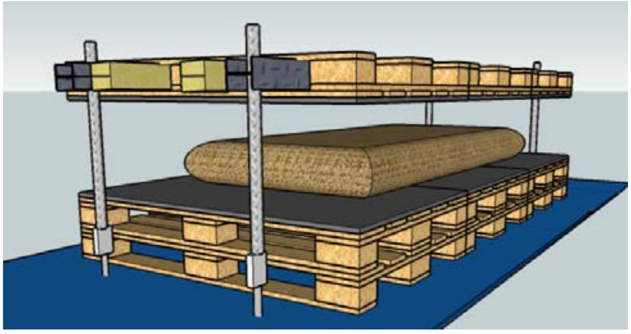

Figure 4. Testing stand used to test dunnage bag 60x120 cm in gap d_x of 10 cm, 15 cm, 20 cm and 25 cm (d_{max} = 25 cm)

Source: Authors

The biggest difference between the measured value of force and the calculated value of force by the CTU Code in a gap of 10 cm was at a pressure of 0.4 bar (9.53 %). The smallest difference occurred at a pressure of 0.3 bar (2.2 %).

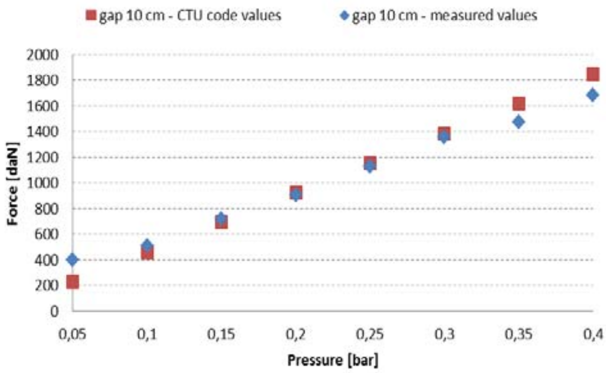

Figure 5. Test results for dunnage bag 60x120 cm in gap dx of 10 cm

Source: Authors

At the gap of 15 cm the smallest difference was at filling pressure of 0.15 bar (5.0 %) and the largest difference was observed at a pressure of 0.2 bar (15.4 %). The curve of the measured values and the curve of the calculated values according to the CTU Code cross between 0.1 and 0.15 bar.

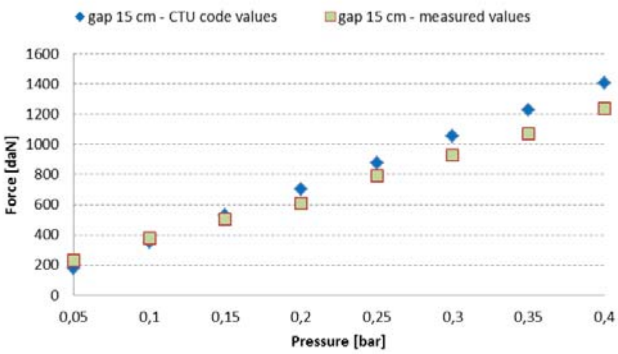

Figure 6. Test results for dunnage bag 60x120 cm in gap dx of 15 cm

Source: Authors

At the gap of 20 cm the smallest difference was at filling pressure of 0.15 bar (2.38 %) and the largest difference of securing forces at pressure of 0.2 bar (9.61 %).

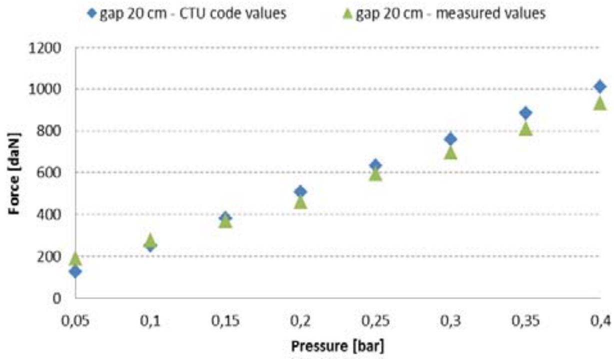

Figure 7. Test results for dunnage bag 60x120 cm in gap dx of 20 cm

Source: Authors

Comparison of forces in a gap of 25 cm gives the smallest difference at pressure of 0.15 bar (10.59 %) and the biggest difference at pressure of 0.3 bar (20.4 %).

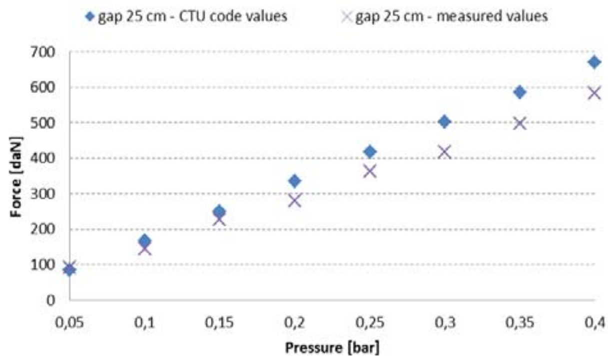

Figure 8. Test results for dunnage bag 60x120 cm in gap dx of 25 cm

Source: Authors

Table 2. Difference between measured and calculated force according CTU Code for measured gaps and selected pressures

Gap / Pressure	10 cm	15 cm	20 cm	25 cm
0.15 bar	-4.16%	5.00%	2.38%	10.59%
0.20 bar	2.31%	15.40%	9.61%	19.54%
0.30 bar	2.20%	13.84%	8.99%	20.40%
0.40 bar	9.53%	13.63%	8.44%	15.02%

Source: Authors

Following figure shows exact securing force difference between the measured and calculated force for different gaps and filling pressures.

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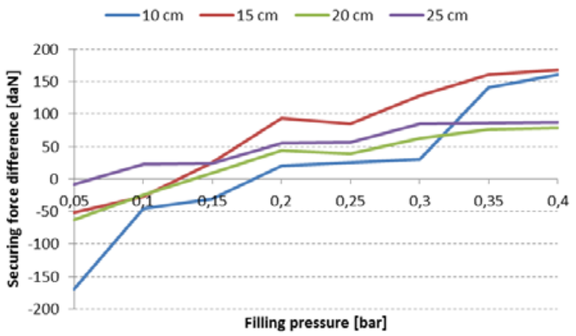

Figure 9. Force difference between measured values and calculated values for dunnage bag 60x120 cm in different gaps and filling pressures

Source: Authors

5. Conclusions

When we compare the values of measured forces and forces which are calculated according to the CTU Code we find out that the calculation of contact surface according to the CTU Code overestimates the contact surface and, therefore, also overestimates the securing force of the dunnage bag. The contact surface according to the CTU Code is a rectangle but in reality it is a different shape. To describe the exact surface of a dunnage bag, more measurements with different sizes of bags, gaps and pressures must be performed.

It is also important to note that this paper provides the results only for the small dunnage bag with dimensions of 60 x 120 cm in gaps to 25 cm and filling pressure up to 0.4 bar. We expect even bigger differences when bigger dunnage bags are used in bigger gaps at higher pressures.

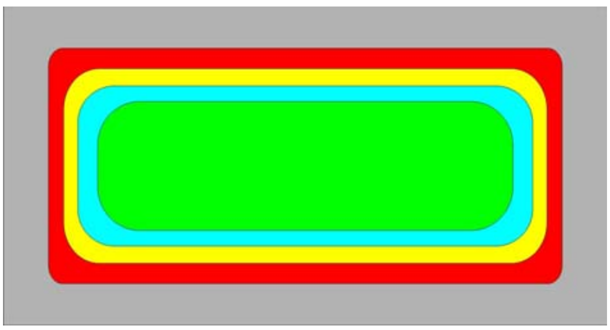

Figure 10. Approximate contact surface of dunnage bag 60 x 120 cm (grey) in a gap of 10 cm (red), 15 cm (yellow), 20 cm (blue) and 25 cm (green) marked by a marker pen during tests

Source: Authors

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The analysis of safety on Polish roads between 2000 - 2010

Marek Jaśkiewicz [1], **Rafał S. Jurecki** [2]

[1]Department of Vehicles and Transport, Kielce University of Technology, Kielce, 25-314, Poland e-mail: m.jaskiewicz@tu.kielce.pl
[2] Department of Vehicles and Transport, Kielce University of Technology, Kielce, 25-314, Poland e-mail: rjurecki@tu.kielce.pl

Abstract This article provides an assessment of the security situation on Polish roads. Statistical data on road accidents that occurred in different provinces in late 2000 - 2010 were analysed and the attention was drawn to the differences in the number of road accidents recorded between them. The analysis of accident statistics and the effects they had on particular provinces was made. They were presented for Świętokrzyskie province and compared to other provinces.

Keywords safety, accident, accident statistics

JEL R41 - Transportation: Demand, Supply, and Congestion • Safety and Accidents • Transportation Noise

1. Introduction

Each year tens of thousands of car accidents are reported on Polish roads. In these accidents, several thousand people are killed, and tens of thousands go to hospitals with more or less serious injuries. As a result of these injuries, many of these people will never be able to regain full physical and mental fitness.

Many authors take in their articles subject causes of road accidents in other countries [1, 2, 3].

In many publications [4, 5, 6], the authors try to make the analysis of the current state of road safety in order to find a way for Polish roads to be safer and in the near perspective to achieve European standards in this field. The authors of this article evaluated the statistical data covering some selected statistical elements, with particular emphasis on their occurrence in different provinces.

2. Accident indicators in Poland

Number of motor vehicles in Poland in recent years has significantly changed. In the past decade it increased from about 14 million to more than 23m, an increase of over 65% compared to 2000.

At the same time, the number of cars has increased from almost 9m to over 17 million. These figures may give some idea of the great development of the automotive industry which had and still has a place in Poland – Fig. 1. Motorization rate of population indicating the number of cars per 1000 citizens in 2010 exceeded the value of 450. This moved Poland to European averages in this area. With the increasing number of cars on Polish roads, the number of road accidents also changed.

Fig. 2 shows the number of road accidents and injured people. Number of road accidents recorded in 2000 decreased compared to 2010 by 48%, the number of people killed fell by as much as 61%, while the number of people injured by 46%. Presented data clearly show a considerable progress in improving road safety.

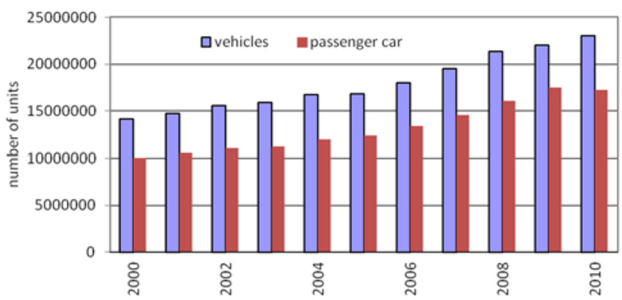

Figure 1. The number of cars in Poland between 2000 - 2010.

A question should, however, be asked whether this improvement in road safety is noticeable? Analysing statistical data, it could be said that in this respect there has been a significant quantitative change.

Unfortunately, data concerning accidents continue to be alarming in comparison with other European countries and we can conclude that there is a long way in order to get close to them as for accident rates.

Poland has been placed on the first position in EU regarding fatalities in comparison to other European countries.

Indicator of the number of deaths per 100 accidents in Poland is one of the highest in Europe, and in 2010 was just over 10, while, for example, in Germany, Great Britain, Italy, Austria and Sweden the figure is less than 2. In Slovakia, in 2009 the ratio was approximately 4.4.

In Germany, where the number of accidents recorded (over 300K) is 5 times higher than in Poland, the number of people killed in them estimates at 4 – 4.5K, which is "only" about ten percent higher than in Poland. The death rate in road accidents in Poland is several times higher than in other EU countries [6]. Fig. 3 shows a decrease in the number of accidents per vehicle.

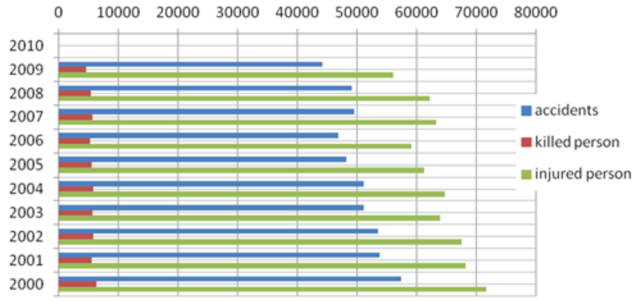

Figure 2. The number of road accidents and people injured in accidents in Poland in 2000-2010.

Figure 3. Decrease in the number of accidents per vehicle.

Interesting observations on road accidents in Poland can be drawn by analysing their presence in each province – Fig. 4, including Świętokrzyskie province.

Important is the fact that the number of accident values gradually decreases in most provinces. Particularly noticeable is the decline, in recent years, of the number of accidents in the provinces: Wielkopolskie, Mazowieckie and Małopolskie.

As shown in Fig. 4 in Poland during the last 10 years, most accidents occurred on the roads of five provinces: Łódzkie, Małopolskie, Mazowieckie, Śląskie and Wielkopolskie. Their area covers more than 35% of the territory of Poland with nearly 55% of Polish citizens living there.

On the roads of the above-mentioned provinces, a total of more than 50% of all accidents in Poland was recorded – Fig. 5. In contrast, however, to the number of road accidents (Fig. 3), where in recent years lower and lower values are recorded, it appears that the share of these events in overall numbers changed slightly (remain almost unchanged).It is worth mentioning that in many provinces such as Śląskie and Łódzkie in 2009-2010, they reached the highest values in the last 10 years, and Wielkopolskie province by far the lowest one.

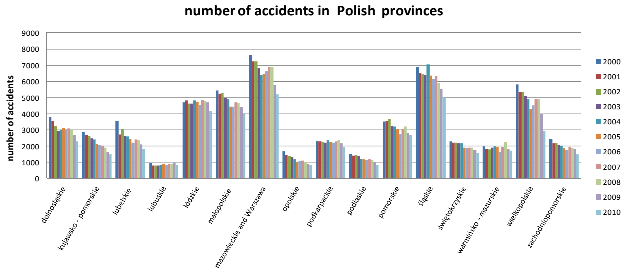

Figure 4. The number of accidents in Polish provinces.

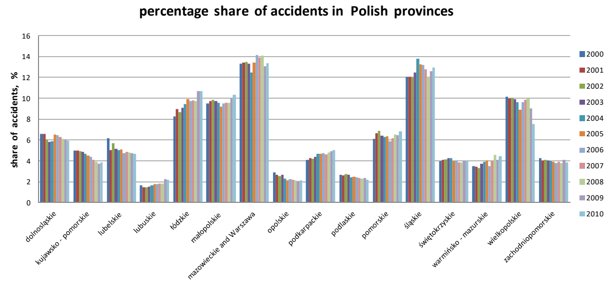

Figure 5. Percentage share of accidents in Polish provinces.

Several thousand people get killed on Polish roads every year. By analysing their number – Fig. 6, it can be said that in terms of the number of most tragic accidents, Mazowieckie province takes a disgraceful first place (along with Warsaw, the region of the Metropolitan Police command). A significant reduction in the number of deaths in all provinces in the period from 2009 to 2010 is worth noting here. Perhaps this is a lasting trend, but in a next few years it will be confirmed.

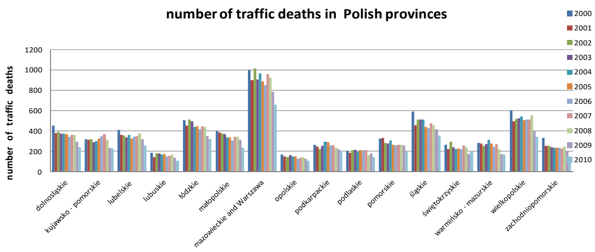

Figure 6. Number of traffic deaths.

Analysing the share of people killed in accidents in relation to the total number of victims in Poland – Fig. 7, it can be concluded that for Mazowieckie province in the years 2000-2010 registered a share of people killed in the amount of 15 - 17%. Other provinces such as Łódzkie, Śląskie or Wielkopolskie record significantly lower results in this respect and their share is 8 - 10%.

Equally important is the fact that the share of the number of people killed in road accidents (Fig. 7) (as well as accidents themselves – Fig. 5) at the end of the period of 10 years does not change significantly, which could mean that each province has its own characteristics including road infrastructure, specific habits of drivers and other features that may determine the analysed data, and which, at the same time, do not change dramatically at the end of the period concerned.

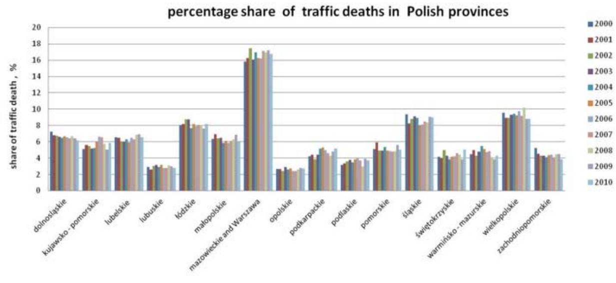

Figure 7. Percentage share of traffic deaths in provinces in 2000-2010.

A similar trend as in the case of accidents and fatalities can be observed by the number of people injured in each province – Fig. 8, and the percentage of their share – Fig. 9. It may be noted that the decline in the number of injured is noticeable especially in 2009-2010, while in most provinces minimum values during the period were reached. In contrast to earlier comparisons, however, we can see a large increase in the number of people injured in accidents in Śląskie and Wielkopolskie provinces.

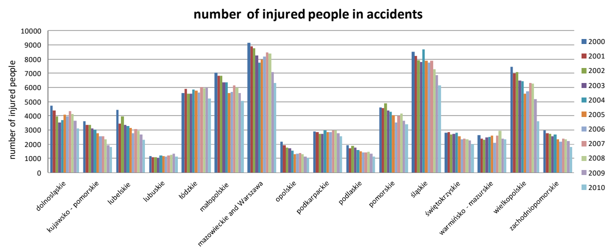

Figure 8. Comparison of the numbers of injured people in accidents.

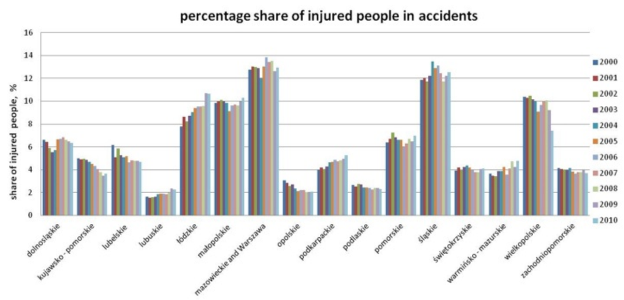

Figure 9. Percentage share of injured people in accidents.

Analysing accident statistics, one can often meet with various relative indicators, thanks to which deeper assessments can be made. One of such indicators is the number of people who died in accidents per 100 accidents - Fig. 10.

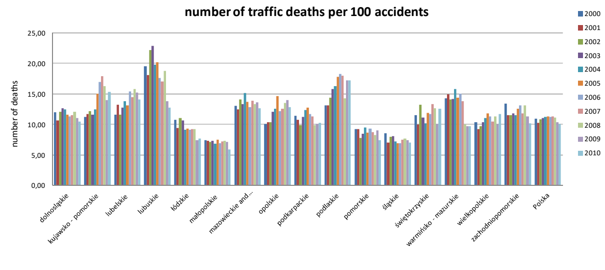

Figure 10. The number of people killed in 100 accidents.

Analysing the graph of Fig. 10, it can be seen that in terms of the number of deaths in accidents in relation to the number of accidents in previously-mentioned provinces, which had the highest numerical values here, relatively "good" results were reached. In the case of Lubuskie, Podlaskie, and Warmińsko-Mazurskie provinces, it can be said that the events that took place on their territories, carried a higher risk of death. A record-holder in this regard is Lubuskie with "top" results in the last 10 years. It should be noted that in recent years the value of the index for this province significantly decreased, while only for the Warmińsko-Mazurski increased. The average value of the number of traffic deaths per 100 accidents in Poland amounts to few more than 10, and only a few provinces like Łódzkie, Małopolskie, Pomorskie and Śląskie have a value below this average.

It should be noted that the rates achieved in Poland are several times higher than the same rates recorded in Germany and Austria.

Table 1 shows examples of indicators for selected provinces. The shaded cells indicate the highest rates of the year, marked in bold suggest smallest values. What is worth emphasizing is the fact that Małopolskie province achieved the best results over 10 years.

Table 1. Indicators of severity of accidents (deaths per 100 accidents)

Province/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Dolnośląskie	11.99	10.61	12.12	12.64	12.42	11.56	11.35	11.52	12.09	11.02	10.51
Kujawsko - pomorskie	11.22	11.67	12.19	11.62	12.48	15.07	16.92	17.86	16.30	14.03	15.30
Lubelskie	11.62	13.23	11.63	12.71	13.84	13.16	15.42	14.51	15.78	15.19	14.07
lubuskie	19.47	18.10	22.15	22.84	19.83	20.23	17.60	17.07	18.76	13.81	12.78
Łódzkie	10.72	9.39	10.99	10.65	9.12	9.34	9.11	9.22	9.20	7.37	7.70
małopolskie	**7.37**	**7.33**	**7.09**	**7.34**	**6.86**	7.53	6.94	**7.22**	**7.36**	**7.11**	**5.87**
Mazowieckie i Warszawa	13.03	12.46	14.05	13.30	15.17	13.72	12.83	13.89	13.31	13.64	12.62
opolskie	10.05	10.35	10.32	12.09	12.59	14.61	12.21	12.51	13.52	14.04	12.80
Podkarpackie	11.43	10.72	9.91	11.22	12.39	12.79	11.70	11.28	9.93	10.12	10.30
Podlaskie	13.09	13.15	14.39	15.80	16.31	17.81	18.33	17.99	14.26	17.20	17.24
pomorskie	9.18	9.19	7.74	8.46	9.55	8.68	9.31	8.70	8.28	9.02	7.44
śląskie	8.52	7.04	7.99	8.04	7.25	**6.91**	**6.91**	7.52	7.71	7.44	7.02
Świętokrzyskie	11.51	9.96	13.22	11.15	10.17	11.91	11.72	13.34	12.64	10.09	12.52
Warmińsko- Mazurskie	14.29	14.98	14.05	14.16	15.77	14.41	15.08	13.81	10.00	9.69	9.74
Wielkopolskie	10.39	9.23	9.70	10.35	11.00	11.79	11.36	10.46	11.33	10.10	11.71
Zachodniopomorskie	13.46	11.50	11.47	11.81	11.55	12.59	13.16	11.82	13.12	11.33	10.17
Poland	10.98	10.29	10.88	11.04	11.18	11.31	11.18	11.27	11.08	10.34	10.06

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However, analysing how the value of the index decreases Fig. 11, it can be said that by 10 years, this indicator decreased most in Lubuskie and Warmińsko-Mazurskie, and least in Kujawsko-Pomorski and Podlaski provinces.

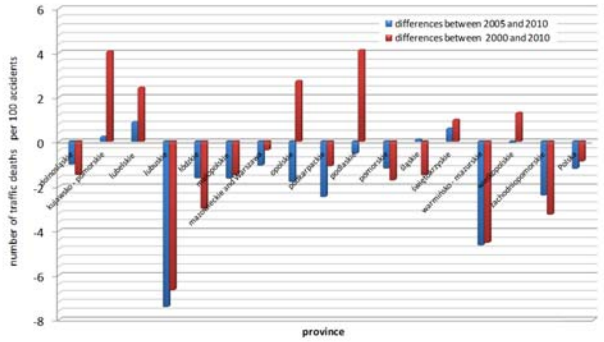

Figure 11. The decrease in traffic deaths per 100 accidents in 2000-2010 and 2005-2010.

Similar analysis can be carried out by estimating the number of injuries per 100 accidents – Fig. 12. In contrast to Fig. 10, where significant differences were noted, all of the provinces reach relatively similar results. High indicators are recorded by Lubuskie province, but in recent years Dolnośląskie takes the first place - Table 2. Table 2 highlights the highest indicator values in a given year. It should however be noted that this figure places Poland in the middle of European countries. For instance, Luxembourg in 2009 recorded a rate of 145.2 injuries and Slovakia 135.3 respectively. In Poland, the relatively highest values are obtained by Dolnośląskie and Lubuskie with Łódzkie recording the smallest values in recent years. Fig. 13 shows the percentage decrease of the injured per 100 accidents in 2000-2010 and 2005-2010.

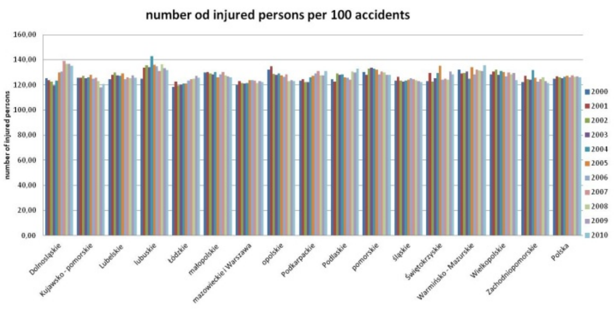

Figure 12. Number of injured people in 100 accidents.

By analysing the statistical data, it can be concluded that the presented results may depend on many factors such as specific features of a province, terrain, particular weather conditions, population, density of road network and many others. It is difficult to assess which of them have a decisive impact.

Table 2. Number of injured people per 100 accidents

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
dolnośląskie	125	123	122	119	123	129	130	139	136	136	135
kujawsko - pomorskie	125	125	127	125	125	127	124	125	**122**	**118**	**120**
lubelskie	124	127	129	127	127	129	124	126	125	127	125
lubuskie	124	133	135	133	142	135	134	131	136	133	131
Łódzkie	**118**	**122**	**119**	**120**	**121**	**121**	123	124	124	127	125
małopolskie	129	130	129	128	130	126	128	130	127	126	126
mazowieckie, Warszawa	119	123	121	121	121	123	123	123	121	122	122
opolskie	132	135	128	127	128	127	126	128	122	123	122
podkarpackie	123	124	122	122	126	127	129	131	127	127	131
podlaskie	124	122	129	127	128	126	125	**124**	130	129	132
pomorskie	130	127	132	133	132	131	128	130	130	127	128
śląskie	123	126	123	122	123	124	125	124	123	123	122
świętokrzyskie	122	129	122	125	129	135	124	124	124	130	128
warmińsko-mazurskie	132	128	129	130	125	134	128	132	131	131	135
wielkopolskie	128	130	132	128	131	130	126	129	128	129	123
zachodniopomorskie	122	127	124	124	131	125	**122**	124	125	123	121
Poland	124	126	126	125	126	127	126	127	126	126	126

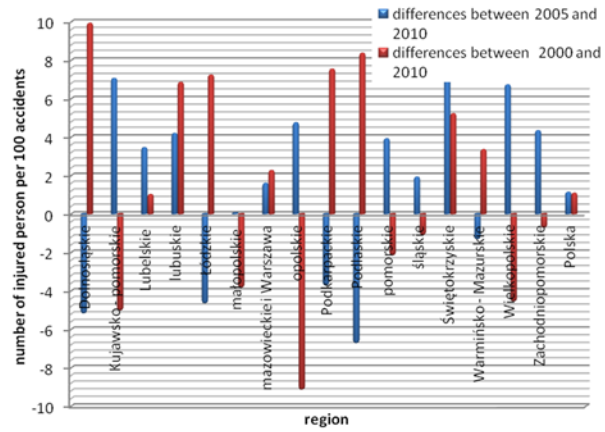

Figure 13. The percentage decrease of the injured persons per 100 accidents in 2000-2010 and 2005-2010.

Fig. 14 shows the number of accidents per number of people living in a particular province [4, 5]. In this respect, Łódzkie (164-185) and Świętokrzyskie (164-185) noted the highest rates in 2000 - 2010.

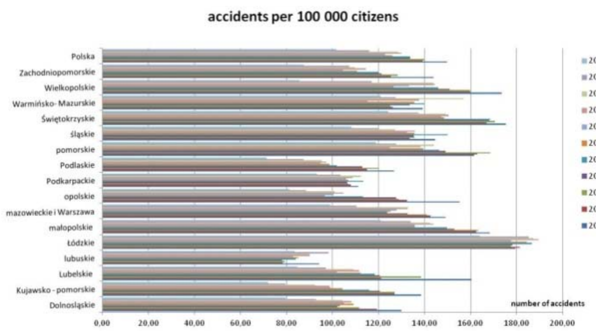

Figure 14. The number of accidents per 100 000 citizens.

In 2010, only 10 provinces had a rate less than the average for the whole Poland amounting to 101.6 (in 2000 it amounted to as much as 150), and this year the best result of 71.3 has been recorded by Podlaskie province.

Similar analysis was carried out for the traffic deaths in relation to the 100 000 citizens of the province – Fig. 15.

The worst results in this area were reached by Świętokrzyskie and Warmińsko-Mazurskie. The average value for Poland in 2010 estimated to 10.22, while in the year 2000 amounted to as much as 16.45. In 2010, the worst result was achieved by Świętokrzyskie - 15.56 where Małopolskie had the best results - the value of 7.1.

For the analysis of the number of people injured in comparison to the number of citizens in the province – Fig. 16, Łódzkie province notes the highest indicators. While the average value estimated for the year 2010 amounted to 128.1, Łódzkie province registered the value of 204.2. Łódzkie and Lubuskie provinces, in any case, record the smallest changes of values obtained at the end of 10 years, while most of the provinces recorded a significant improvement in this indicator at that time. Fig. 17 shows an annual decline in the relative rate of injuries per 100 000 citizens.

While studying the number of accidents on Polish roads, we may also consider a very important aspect related to road infrastructure - the quality and type of roads [7].

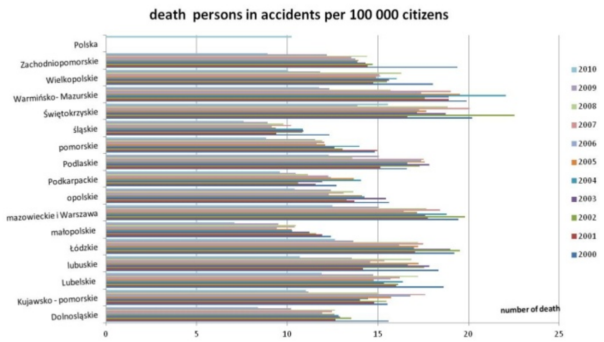

Figure 15. The traffic deaths in accidents per 100 000 citizens.

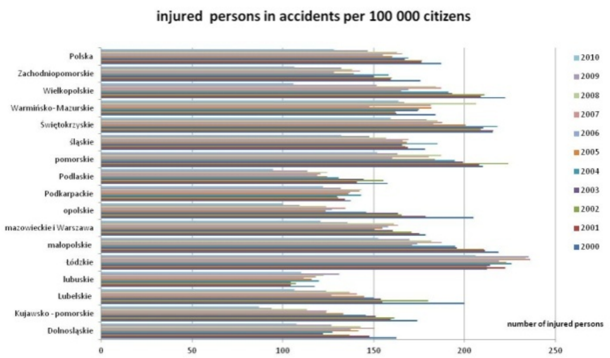

Figure 16. The injured in accidents per 100 000 citizens.

Analysing the percentage of accidents that have occurred at different types of roads, it can be stated that, despite ongoing and constant road investments for several years in this area, relatively few changes have taken place. A very important aspect of the studies carried out for many years, is the fact that accidents often occur in Poland on two specific types of roads (Fig. 18). These are single-lane two-way roads (without separated lanes, which in the case of a head-on collision the most tragic consequences). These roads, unfortunately, are mostly common in Poland and roads of two one-way lanes (like expressways with a much lower standard of safety).

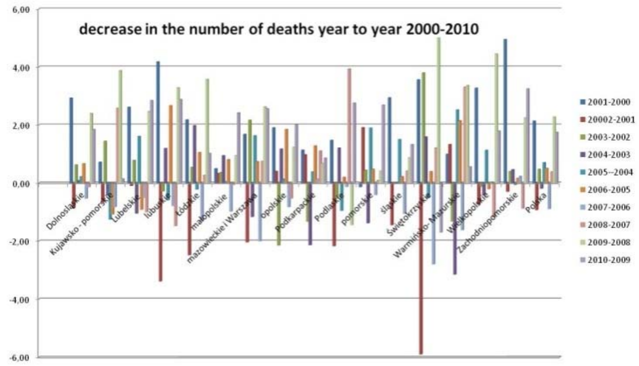

Figure 17. The annual decline in the relative rate of injuries on 100 000 citizens.

The results shown in Fig. 12 confirm that most accidents happen on single-lane two-way roads - Table 3 and on the roads with two single-way roads - Table 4.

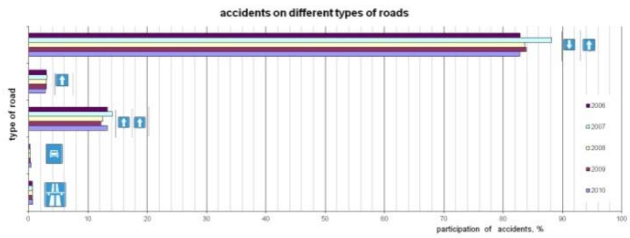

Figure 18. The percentage of accidents depending on road type.

The important fact is that 95% of all accidents occur on these two types of roads [8]. On other roads, drivers cause significantly fewer road accidents: motorways and expressways - a total of about 1% - Tab. 5, one-way roads around 3%.

Table 3. Accidents and their consequences on two-way single-lane roads

	2010	2009	2008	2007	2006
Accidents, %	82.8	83.9	83.7	88.2	82.9
The killed, %	88.6	88.8	89.2	88.7	88
The injured, %	83.2	84.2	84.1	83	83.2

Table 4. Accidents and their consequences on the road of two one-way lanes

	2010	2009	2008	2007	2006
Accidents, %	13.3	12.2	12.5	14.1	13.3
The killed, %	8.9	8.4	8.8	9	9.3
The injured, %	13	12	12.3	13.1	13

Table 5. Accidents and their effects on motorways and expressways

	2010	2009	2008	2007	2006
Accidents, %	13.3	12.2	12.5	14.1	13.3
The killed, %	8.9	8.4	8.8	9	9.3
The injured, %	13	12	12.3	13.1	13

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Which is equally important to emphasize is that on the roads without separated lanes (majority in Poland), significantly more people died in accidents – Fig. 19. In cases of accidents on single-lane two-way roads almost 88% of people die, on the roads with two lanes close to 10%. The remaining 2% of people die in accidents on other types of roads [8].

After analysing the above-mentioned data, we may hopefully accept efforts aiming to modernize Polish roads, construction of expressways and motorways, which according to data forwarded before, carry the smallest risk of traffic accidents. So far, despite the attempts made in this regard, a significant change in the percentage shares of accidents on various types of roads cannot be observed.

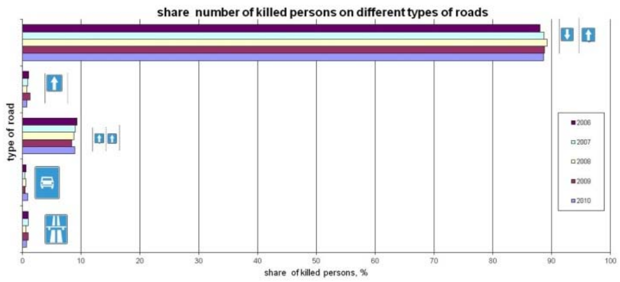

Figure 19. The percentage of traffic fatalities depending on road type.

A similar analysis of the number of people injured also confirms the danger to which drivers are exposed while driving vehicles on these two most dangerous types of roads. For these types of roads, the sum of the share of people injured is over 90%.

Fig. 20 indicates the length of the safest types of roads in particular provinces in terms of the number of accidents and traffic deaths, that is expressways and motorways. By analysing this data, it can be seen that the length of such roads in most provinces is growing, but these are the provinces where, at the end of 2009, such roads did not exist at all (Podkarpackie, Podlaskie). The location of these roads is also uneven. Most of expressways and motorways are located in the Wielkopolskie, Śląskie and Dolnośląskie provinces.

It should also be noted that the number of roads since 2005 has increased from 785 km to over 1370 [9].

Based on accident data presented, there is any significant impact of infrastructure projects on road safety visible yet, as expressways and motorways in Poland constitute only about 0.6% of all roads with improved surface. Another problem is the accessibility of these roads. Many road users usually select alternative routes to reduce travel costs. Drivers of vehicles over 3.5 tons, try not to use the roads on which fees are collected.

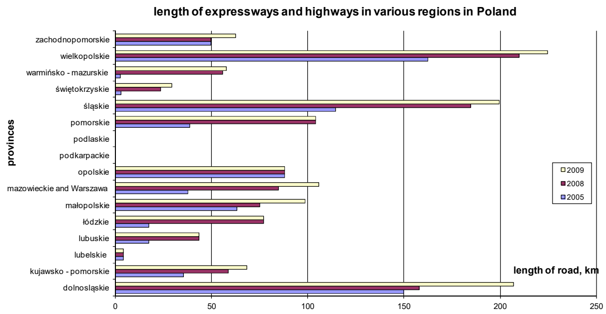

Figure 20. Length of expressways and motorways in each province.

3. Conclusions

Polish roads for many years have been one of the most dangerous in Europe. Backlog inherited from the previous system, makes Polish roads transport inefficient. The number of cars increasing from year to year increases traffic congestion. Single-lane two-way roads are dominant in Poland. Head-on collisions are most common on such roads. As it is well known, a head-on collision is one of the most dangerous one. At the moment of impact, a human body is exposed to great inertial forces caused by a sudden change in speed. For instance, a head-on collision of vehicles moving at speeds of 50 km/h causes the head of a driver or a passenger accept the delay from 60 to 500g depending on the place of impact of the head [10, 11, 12,13]. Thus, the presence of such large delays in a very short period of time brings with it consequences which are visible in statistics. In spite of such data, it can be stated with satisfaction that the number of accidents and traffic deaths still decrease. But is the trend constant? Using the patterns of other European countries, especially after Poland's accession to the European Union, significant improvement (using EU funds) of road infrastructure has been performed. Unfortunately, in many provinces no investment in expressways not to mention the motorways has been realised, and these roads are the safest as it has been shown in this paper.

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The Genesis and Metamorphoses of Risk

Tomáš Klieštik[1], **Miloš Birtus**[2]

[1] Department of Economics, Faculty of Operation and Economics of Transport and Communications, University of Žilina
[2] Department of Management, Faculty of Education, Catholic University in Ružomberok

Abstract Each business activity and also an individual person face risk every day. But what is risk? People have different attitudes to risk. Natural survival instincts make some people use all possible means to avoid injury or loss. These decisions are not decisions but more of inner instincts of survival. If we move from an individual to an organization, standards and rules become more complex and more formal. When activities become more complex, instinctive and institutional patterns of behaviour forming the basis of personal risk management become inadequate and decisions become more complicated. The theory of risk has been a subject dealt with in many available books by domestic and foreign authors and risk management as such has been a subject of detailed research. We can even claim it constitutes an independent part of the theory of economy.

Keywords Risk, decisions, uncertainty, investment alternative, undesirability

JEL D81 - Criteria for Decision-Making under Risk and Uncertainty, F47 - Forecasting and Simulation: Models and Applications

1. Introduction

People have always liked entertainment, games and bets. Even though they do not only pursue their leisure but lose their money as well,[1] it is not clear whether they have given the likelihood of their successes and failures a serious thought. An accident was considered a part of the nature or message from gods. People held absolutely fatalistic attitude towards the future. In 1650s the French mathematician Blaise Pascal, who is also considered a father to modern exact approaches to selection, chance and probability, started to deal with the theory of probability. In centuries to follow other great personalities like Bernoulli, Bayes, Gauss, LaPlace and others developed his ideas. It is their studies and works that enable us to understand the world of uncertainty with much more efficiency. People living before Pascal considered risk something inevitable, out of their control. But even nowadays there is no definite approach to risk. We are able to count orbitals in our solar system, clone animals, modify food genetically, etc. but when it comes to predicting a particular share price in a month time, we find ourselves in the dark. Despite the knowledge potential of the mankind is increasing inevitably, there is still no sufficiently reliable methodology to predict, quantify, and minimize or diversify risk.

2. Uncertainty versus Risk

It may seem that the terms risk and uncertainty are synonyms, but it is not so[2]. Each of these values has a different character. Uncertainty is a broader term related to such variations in which probability of occurrence or size cannot be measured. Moreover, uncertainty is the probability of the result of an event which has to be borne by all of us regardless of whether this event bears upon us or not. But in the moment we decide to undergo this uncertainty, the risk that is created concerns us only. Risk is something borne by an individual or a team as a consequence of undergoing an uncertainty. But uncertainty itself does not imply that somebody must take the risk. We all bear the uncertainty of Nigerian exchange rate, but that does not mean somebody will trade this currency. In general we know three basic types of uncertainty:

- known,
- unknown,
- undetectable.

Known uncertainty is certain in its occurrence and can be determined using math formulas providing there are known and well defined facts. *Unknown uncertainty* is not possible to be derived explicitly. This one is detected in the course of time, events and activities, and therefore its behaviour is detected by the use of simulations and other form of approximations. *Undetectable uncertainty* is revealed after the actual event has taken place. Typical examples are natural disasters. Known certainty is a subject to traditional analysis that relies on known values. Risk analysis deals with unknown and undetectable certainty.

Uncertainty can also be divided into:

- *endogenous uncertainty,* related to the company internal processes and reflecting uncertainties within those particular projects that affect technical difficulty, timetable and uncertainty of project funding.

[1] E.g an excellent novel by M. F. Dostoyevsky – The Gambler
[2] Experts strictly distinguish risk and uncertainty.

- *exogenous uncertainty,* closely related to market factors such as changes in demand, competitive behaviour, changes in interest rates and price levels, etc.

Uncertainty is an objective form of the real world around us and is manifested in ambiguity during real processes. There are two aspects of uncertainty:

1) ontological aspect – uncertainty is conditioned by existence of randomness as a manifestation of necessity,
2) gnoseological aspect – uncertainty is conditioned by the incomplete display of real phenomena in human consciousness.

The source of uncertainty is then an object as well as an entity. Taking into account its character and source, uncertainty is an objective element accompanying human activities focused on influencing and transformation of the future. When preparing these activities, a decision-making body[3] is not able to spot all causal links between selected procedure (e.g. selected investment alternative) and its consequences. Uncertainty of the consequences of a selected procedure may only be smaller or bigger, i.e. it cannot be removed completely. Uncertainty creates a danger that the implementation of a certain alternative will cause a negative variation of planned or expected effects and those that were achieved. The danger of negative variations is seen as *risk*. The history of the term risk is not clear. We can find different opinions regarding the language of origin. The term risk (Petit 2007) is first seen in Italian language regarding sailing - the word *risico* represented the ledge which was to be avoided. Then this term started to be used to describe exposure to adverse circumstances. (Acerbi 2002) claim the word risk comes from Arabic *risq* or Latin *riscum*. The word risq means random outcome and riscum means a chance but also an adverse event. The term risk is not only known in Europe. Damodaran (2012) says that the Chinese expression for risk in Chinese characters in Figure 1 is the best representation of its meaning.

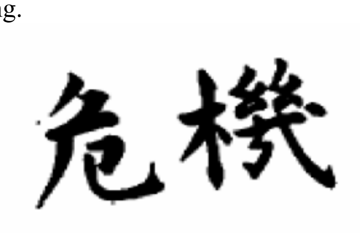

Figure 1. The word risk in Chinese characters.

The first character means danger and the other one opportunity. These two characters express the relation between the opportunity, which can be understood as profit and danger which represent risk.

A modern English word *risk* originated in 17th century and was derived from the French word *risque*, which is nowadays mostly the synonym of a negative event.

There are several technical, economic or social definitions for the term *risk.* There is no generally accepted definition. Just to illustrate this, let us look at some of the definitions. Those most often quoted define risk as:

- the uncertainty related to possible occurrence of events,
- the danger increasing frequency or severity of losses,
- the likelihood of injury, failure,
- the combination of likelihood and loss,
- the probability that the actual loss value deviates from the expected values,
- the likely value of the loss incurred by the risk recipient by hazard scenario execution, expressed in monetary terms or other terms,
- the cumulative effect of the likelihood of uncertain events that may positively or negatively affect the objectives of the project,
- the volatility of financial variables (portfolio value, profit) around the expected value,
- the potential for gain or loss on investments or business (the speculative risk),
- the danger of negative deviations from the target (so called net exposure),
- the uncertainty associated with the development of asset value,
- the mean value of loss function,

The abovementioned selection of definitions is not comprehensive at all, but it is clear they have a certain common feature – risk is not a value leading to exact values but its value is an estimate, either empirical or analytical. Analytical estimate uses mathematical description of an event; we distinguish between a priori estimate (knowledge of the random behaviour of events as sources of danger from the past, an event is a priori known but its features are not) and a posteriori estimate (assumption that the event may occur, prediction of the complex event, future behaviour based on partial event behaviour). Empirical estimation is brought up if there is no ground for analytical estimate. Then it uses analysis based on experience. This type of estimate is also called a qualified estimate. When talking about company financial management, it is important to see its analytical meaning, i.e. it can be defined mathematically. This is the approach most often met with in literature and therefore we will use it when analysing risk. Just to make this approach even clearer, let us see some of other characteristics or definitions of risk:

"Risk is such uncertainty, in which various, mostly mathematical and statistical methods enable us to quantify the likelihood of how much real conditions will diverse from estimate." (Bringham – Ehrhard, 2010, p. 369)

"Risk means various uncertainties that can be measured using statistical methods. Uncertainties are random phenomena that cannot be measured exactly, i.e. we can only make assumptions." (Hertz, 1976, p. 95)

"Risk is a type of uncertainty in which we do not know the future value of a variable but it is possible to assign - using standard statistical methods (objectively) or estimate (subjectively) - each possible state the likelihood of their occurrence. Therefore it is a quantifiable uncertainty, where quantification is based on probability distribution. "(Fotr, 1999, p. 207)

"Risk is a potential financial loss of a body, i.e. not an existing realised or unrealised financial loss, but a future

3 a man or a group (e.g. management or general meeting of shareholders)

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loss arising from the financial or commodity instruments or financial or commodity portfolio." (Kao, 2000, p. 52)
"Risk is a danger of a damage or a loss and there is always a certain negative valuating associated with it. This meaning of risk is closely related to its identification with negative events likelihood." (Jílek, 2000, p. 76)
"Risk is a term which defines how much uncertainty there is. The bigger uncertainty, the bigger risk. Risk is a degree of uncertainty." (Fabozzi - Peterson, 2003, p. 401)

Diversity of risk definitions may evoke the fact that each author has a different concept. But it is just the opposite. In general all these definitions define risk as a variation from a desired or planned state. Some authors however see risk only as a negative variation while the other group see also a positive variation as risk.

Risk and uncertainty – While some definitions of risk focus only on a certain event likelihood of occurrence, the more complex ones do not operate with likelihood of occurrence only but also with the consequences of the event. Earthquake is an example of such event. The likelihood of its occurrence may be small, but the consequences in case it occurs would be so catastrophic that it is necessary to categorise it as a highly risky event.

Risk and threat – Some disciplines have different approach to risk and threat. Threat is defined as an unlikely event with widespread negative consequences, where analysts cannot determine the likelihood. On the other hand, risk is defined as a highly likely event, where analyses have sufficient information to determine its likelihood as well as consequences.

All outputs versus negative outputs – Some definitions of risk tend to focus on negative (undesired) scenarios, others are more extensive and include risk variability. In the field of industry risk is defined as a result of likelihood of an event that is considered negative and as a determination of an expected loss as a consequence of the event occurrence.

Risk is always associated with the following terms:

1. **uncertainty of outcome**, the bigger risk, the broader margin between possible results. When talking about risk, there are at least two meaningful and realistic alternatives of solution;
2. **undesirability**, which means that at least one of two results is undesirable for the company or it has a negative effect. If both results are desirable or have a positive effect, there is no risk in decision-making process.

Risk analysis brings some problems with terminology, which is often not uniform. This fact is caused by a wide range of meanings of the word risk, usage in different fields and ambiguity of some terms. Even standards dealing with risk management use different terminology. Even though regular communication among experts is not usually affected by this fact, there may be some problems when it comes to translation into different languages.

Risk factors that can influence a decision-making situation and which should be taken into account by managers in solving various decision-making processes include:

- The purchasing power of the population and the change of demand associated to it,
- changes in the prices of manufactured products,
- changes in input prices,
- changes in technology,
- failure rate and quality of production and inputs,
- employee morbidity and sick leave,
- changes in foreign exchange rates,
- changes in monetary policy and the associated changes in interest rates,
- changes in macroeconomic and national economic policy of the state,
- legislative changes,
- changes in international economic and political environment,
- weather influence, occurrence of illnesses,
- environmental disasters and accidents,
- etc.

3. Ways to reduce risk

Rational risk assessment as a relation between the potential benefits (effects) and losses is not the only criterion. Risk analysis should include lines of actions that would reduce modifiable risk factors but also eliminate (mitigate) its negative impacts. In general we know two kinds of approaches to protection against risk (Valach 2007):

- **Eliminate the causes of risk and thus eliminate risk** (e.g. to eliminate competition using economic or political power.) This way of protection against risk is also called *offensive approach to risk.* Complete elimination of risk is rather exceptional.
- **Reduce the adverse impact of risk to an acceptable level** (e.g. insurance, diversification, etc.). This approach is used more often than the first one. It is called ***defensive approach to risk.***

Nowadays there is a wide range of tools, possibilities and procedures to reduce risk, mainly the following ones:

1. **Diversification** – Diversification means to diverse risk into more entities and thus to reduce risk in general. Investments get diversified if we put capital into more assets. Raising capital diversifies by spreading among several lenders. Purchase from multiple vendors means diversification. Production can diversify by producing several kinds of products in several regions. Sales are diversified by sales to multiple customers at home and abroad. There are several types of diversification:
   - *Vertical diversification* - production program has been extended by successive production stages; e.g. if the company produces a final product and purchases intermediate products or components, it may opt for its own production of these components. It reduces the dependence on suppliers.
   - *Horizontal diversification* – is in fact expansion of the production program of other products (services) of different nature. The horizontal diversification consists of two subspecies: a related diversification and diversification into unrelated areas. In a related diversification, production activities are expanded into an area linked to the

original one by a factor, for example a shared know-how. Diversification into unrelated areas, as the name reveals, has nothing to do with the original production activity of the company.

- *Geographical diversification* - a distribution of business in several countries. The country can be chosen on basis of several criteria, for example tax dumping, less expensive but skilled workforce, benevolent environmental policy, foreign investment support system and tax breaks, and so on.
- *Diversification in terms of suppliers* – company should strive to ensure material and energy inputs from multiple vendors, thereby reducing the risk of supply failure.
- *Diversification in terms of customers* - a sufficient number of customers ensures that insolvency or resentment of any of them does not significantly deteriorate the venture.
- *Diversification of investments.*

Depending on whether the hazards could be completely eliminated using an appropriate method we can distinguish between non-diversifiable risks (market, systematic) and diversifiable risks (non-systematic). Diversification can protect the business only against diversifiable - systematic risks.

2. **Contractually agreed measures -** in practice we may encounter several types of contractual arrangements. The most commonly used include:
   - *Agreements on safeguards.* The guarantee may be property, movable property and assets of the debtor. The lender is thus protected against credit risk.
   - *Provisions on the conditions enabling changes in interest rates by the creditor.* Such conditions tend to be included in credit agreements, if the loan was granted at a fixed interest rate. The lender is thus protected against the loss of interest in case the interest rate in the economy is growing.
   - *The agreement between the exporter and the importer about the currency in which the delivery will be invoiced and paid.* If the exporter expects his currency to be weakened in relation to that of the importer, he will be interested in invoicing and payment in the currency of the country of the importer. It is because after the collection of payments in a stronger currency, once he exchanges the payment, he obtains more units in their (the weakening) currency. And vice versa - if the exporter assumes a strengthening of the domestic currency, he will be interested in invoicing and receiving payment in local currency. Thus if it is necessary, he will gain more currency units of the importing country for the domestic currency. Interests of the exporter and importer are contradictory on this issue. The currency they both agree on depends on the bargaining power of partners - it can be a completely different currency (third country).
   - *The inclusion of a currency clause into payment obligation agreement.* The clause specifies how partners will participate in covering the difference resulting from change in the exchange rate between the time of the initial commitment and the time of payment. It is a part of the so-called agreement on security clauses.
   - *Barter agreement.* It represents a supply of goods for goods. It is a defence against not paying to customers and in case of the international exchange of goods defence against foreign exchange risk.
   - *For payments associated with the international movement of goods and services* it is possible to cover the exchange rate risk by increasing supply price, by demanding an advance payment from the customer, or demanding payment in advance. All these measures are disadvantageous for the consumer, and therefore reduce the competitive ability of the supplier. The agreement is only possible in low sales negotiation position.
   - *Factoring and forfaiting* means selling a short-term or a long-term debt to the factor (forfeiter), which then takes both the risk that a borrower defaults (*credit risk*) as well as any *foreign exchange risk.*
3. **Flexibility -** Adverse consequences from exposure to the market environment and the occurrence of certain risks can be reduced by flexibility of the investment project, which means the ability to respond quickly and without incurring excessive costs to various changes. A typical example is the choice of universal production equipment to ensure a wider range of production and the possibility of processing a wider range of raw materials. It is not appropriate to apply the concept of flexibility only to the manufacturing facility, but it needs to be applied in every activity of the company, for example the choice of financing the purchase of capital. Acceptance of flexibility as a tool for reducing the risk of investment projects is usable in their conception, in the variant project processing and compatibility between different variants, allowing for adverse conditions to move from one option to another option. Greater flexibility can be reached by:
   - *production of a wider product range,* which allows a flexible respond to fluctuations in demand simply by changing the production schedule,
   - *ensuring versatility of the production facilities, and technologies,*
   - *leaner organizational structure,*
   - *processing a wider range of raw materials and semi-finished products, or by using several types of energy* (or drawing it from multiple vendors), which helps reduce the risk caused by unavailability.
4. **ALM - Asset Liability Management -** is a process of active management of the company balance sheet to create the optimal balance between expected revenues and expenses and related financial risks, i.e. the company is trying to mitigate the risks by time and material reconciling of their assets and liabilities, or cash inflows and outflows. ALM originated as a

management discipline around 1970. The base was to balance cash receipts and expenditures in the time frame so that the company would not become insolvent in any period of time. Gradually this principle developed in other areas:

- *Management of assets and liabilities as a tool to mitigate exchange rate risks* - comparing assets and liabilities as well as income and expenditure in foreign currencies in order to achieve a settlement of claims and liabilities of an entity in different currencies, and when they fall due. The company eliminates exchange rate risk. Natural hedging - a settlement of the total amount. It is important for the reconciliation of expenditure and income in another currency at a given company also to be achieved in the time distribution, which means in different periods of the year. Net exposure - predominance of expected expenditure over income is the amount that is exposed to exchange rate changes.
- *Management of assets and liabilities as a tool to mitigate interest rate risk* - the comparison of interest-bearing assets and liabilities of the company in terms of their sensitivity to changes in market interest rates as a prerequisite for adopting measures to mitigate interest rate risk. If the financial market interest rates change, the amount of paid and collected interest on company payables and receivables, which were agreed with floating interest rates change as well. When market interest rates change, the market value of bonds forming part of the company financial investment change as well. The market value of bonds at interest rates falling grows and when interest rates grow, it decreases.

5. **Risk division** represents a means of reducing risk, where risk is distributed among two or several parties involved in the implementation of a business project or activity.
6. **Risk transfer –** means shifting risk to others. In any case, the entity assuming the risk requires some compensation, it is therefore necessary to assess the advantage of this approach properly. It may be carried out in the following ways:
   - *entering into long-term purchase contracts* for the supply of raw materials and semi-finished goods under previously agreed conditions, for example at fixed prices,
   - *entering into contracts for the sale of products under predetermined conditions* applicable to e.g. sales volume (minimum volume production requirement),
   - *renting production facilities, or other means (leasing),*
   - *outsourcing* is the transfer of in-house activities generally unrelated to the main activity of the company to an external entity (such as a subcontractor). Outsourcing is therefore a special form of outsourcing of previously performed procedures, in which fixed length and activity is a subject to a contract. This makes outsourcing different from other "partnerships",
   - *delaying deadlines for concluding contracts* for specific projects, usually of a technical nature (e.g. development of new products and technologies) until knowing the real costs,
   - *futures (hedging)*
7. **Insurance -** in the case the insurance company enters into a contract with an insurance company which undertakes to repay any damages clearly specified in the contract. In return, the company commits to regular payments, called the premium, which is included in the cost. In the past it was all about insurance against so-called net exposure, e.g. fire, flood, etc. Currently, there is an increasing trend of insurance against business risks such as investments abroad and so on. Insurance is generally characterized as the creation of a centralized monetary insurance fund by contributions of insured entities at risk. However, a company must consider the financial relationship between the amount of premiums paid and the likelihood of an insured event before contracting insurance.
   But only "insurable risks" can be insured, which means risks that meet the following criteria:
   - *large scale criterion* - large number of entities exposed to risk,
   - *the feasibility of risk criterion* - the risks must be relatively independent, must not be significantly positively correlated (feasibility of risk must not occur simultaneously in all insured entities),
   - *quantification criterion* - this means in practice that commercial insurance company must be able to quantify the losses incurred by the insured event,
   - *economic risk acceptance criterion* - commercial insurance companies only insure those risks that are across the board and staggered. The insurance company is thus able to achieve economic equilibrium of the insurance,
   - *criterion of randomness of risk* - that is, there must not be 100% probability of occurrence of an insured event.
8. **Avoiding risk -** risk avoidance tactics should be applied very cautiously. This approach is justified in unacceptable risk when the business projects failure could result in significant distortions of the financial stability of the company, and eventually lead to the decline of the company. Inadequately assessed risk solution is gambling. But even excessive risk avoidance can lead to serious financial problems. Entrepreneurship is not possible without accepting risk - if the entrepreneur avoids the risk too much, more aggressive competitors would push him out of the market. We always have to consider which risks can be avoided without major threats to the expected result. Knowing what specific risks is the plan exposed to can help avoid certain risks. If, for example, we find out that some of our customers risk bankruptcy, we stop deliver him and thus avoid a bad debt - we avoid the risk of non-payment, etc. Avoiding risk may be done in a number of ways:

- *to withdraw existing markets* by divestiture, liquidation, product group spin-off or business unit of the parent company spin off,
- *to ban high-risk activities and transactions* by adopting a system of limits on acceptable risk,
- *to stop specific activities with unacceptable risk* by changing plans, objectives or moving funds,
- *to avoid risky activities* not related to the development of the company in accordance with the approved strategy,
- *to prevent capital and investment projects* with high risk and low return,
- *to eliminate the identified hazards* by designing and implementation of internal preventive processes.

9. **The use of force -** procedures by which the company forms a competitive environment in an effort to gain a dominant position, that means the company will focus on the removal or elimination of risk through the use of power, dominance or competitive advantages of the company. Lobbing can also be put to this category.
10. **Obtaining additional information -** a different kind of market and marketing analysis before introducing new products to the market, gathering information about competitors. This effort may lead to delays in business decisions, which can have a negative impact.
11. **Self-insurance -** a policy of an undergone risk self-insurance may be done in the company through the reserve to cover losses incurred. According to standard accounting procedures reserves for anticipated risks and losses are based on the precautionary principle. In particular, the cost of demolition, remediation work, compensation, fines and penalties, obligations under the guarantee liability, litigation and such. It is therefore clear that reserves are potential liabilities of uncertain amount and indeterminate duration. They can include interest-bearing and non-interest-bearing liabilities, short and long term. The correct procedure would therefore be the assignment of liability provisions in the category which would reflect their commitment. Lack of this particular form is that generally the entity is unable to establish reserve funds in the amount that would cover a greater financial loss. In addition, there is a problem, in what form financial reserves should be maintained to bring a reasonable return, but at the same time, be readily available if necessary.

4. Conclusion

Entrepreneurs may avoid risk mostly if they review profitability and riskiness of all project variants in form of financial plan well in advance. It is a task of a manager to choose the best variant. Basic criteria for that are: profitability (cash benefits promised by the investment) and riskiness (likelihood of project failure), which are proportional. Each company has its own approach to risk. This approach can be represented by so called indifference curve, which depicts the relationship between a risk rate and a required yield rate. Basic yield rate represents no risk investment. All points on the indifference curve are equally acceptable for the company. Desirable variants lay above the indifference curve, undesirable ones under the indifference curve. Apart from negative aspects of risky choice alternatives there is also a positive aspect. If the choice of an alternative is connected to some danger of not fulfilling target value of a criterion, then there is generally also a possibility of exceeding this value that means some hope to get a higher effect that a planned one was (possibility of a positive variation). It is typical for risk decision-making that low risk alternatives have a very little hope to exceed desired effects, while higher risk alternatives are "much more hopeful" in terms of achieving higher effects that the planned ones are. Therefore this fact brings some dilemmas into risk alternatives evaluation.

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The Risk Analysis in Public Passenger Transport

Miloš Poliak[1], Štefánia Semanová[2], Katarína Kilianová[3]

[1]University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, Žilina, 010 01, Slovakia
[2]University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, Žilina, 010 01, Slovakia
[3]University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, Žilina, 010 01, Slovakia

Abstract The paper deals with the risks related to providing public passenger transport. The risks are divided into two groups: cost and revenue risks. The paper describes possibilities of risk allocation among contracting parties when providing transport services.

Keywords transport, financing, risk, factor, region, public

JEL R48 - Government Pricing and Policy, H40 - Publicly Provided Goods - General

1. Introduction

Under current conditions in terms of general economic interest, the public passenger transport services cannot be provided on a commercial basis. Therefore, the mechanisms arise by which the services in public transport are provided in order to ensure the access to basic population's needs such as work, health, and education particularly in the time of low demand. At present, the following mechanisms are used: the award of exclusive rights to public service operators[1], and the grant of financial compensation to public service operators. The mentioned principles are also incorporated in EU legislation (Regulation (EC) No 1370/2007 on public passenger transport services by rail and by road), but also in national legislation of SR (Act No 56/2012 on road transport and Act No 514/2009 on the transport on railroads). The problem is the determination of financial compensation which includes a share of reasonable profit. The reasonable profit must depend on level of risk-taking. However in practise, it is determined as a percentage of economically justified costs. But this method is not correct because the operator who efficiently manages and achieves lower costs, also achieves a lower level of reasonable profit in comparison with the operator who provides comparable performance but at higher costs. Therefore, the aim of the paper is to point out the existence of business risk in public passenger transport.

[1] the public service operator is considered to be a person who performs transportation, operates the means of transport; in some regulations the term "carrier" is used.

2. The Risk Analysis in Public Passenger Transport

There are several papers dealing with the risks and their allocation between operators and authorities (e.g. Stanley and van de Velde, 2008; Hensher and Stanley, 2003; van de Velde, Veeneman and Shipholt, 2008) according to which it is necessary to divide the risks into two groups - cost and revenue risks.

2.1. Cost Risks

The cost risks are associated with a cost calculation when contracting in public economic interest. In public service contract, it is necessary to agree on a price for realized performance which consists of the costs and profits of public service operator. In the case that the operator assumes the cost risk; it is necessary to agree on a scope of realized performance for the contract period and economically justified costs per unit of the realized performance between operator and authority. The cost risks can be divided into two groups (van de Velde, Veeneman and Shipholt, 2008):

- operational cost risks which are related to the difference of the anticipated costs calculated and the actually observed costs after performance realization. The reasonable profit must depend on an allocation of this risk. When the operator does not assume the risk and after realization of performance he proves eligibility of costs to authority for the purpose of compensation, the operator takes no cost risk for the performance realization. In the case that the agreed unit costs in public service contract are final, the operator assumes the cost risk and this should be reflected in appropriate level of reasonable profit.

The operational cost risks can be further divided as follows:

- o external operational cost risks - the risk that cannot be influenced by the operator at all (e.g. cost increasing due to flooded streets in the event of natural disasters). This group can also include the risk which can be influenced by operator indirectly or only in a small extent (e.g. changes in energy prices during the contract period, change of employees' costs, etc.)
- o internal operational cost risks – the risk that can be influenced by the operator, e.g. the costs of maintaining the vehicle fleet (the operator can decide on the maintenance process in order to avoid failure of vehicle and higher costs)

- investment cost risks are related to the difference of the anticipated life of the fixed assets of the operator. While providing public passenger transport it is primarily the means of transport and infrastructure (e.g. bus and tram stops, tram tracks, etc.). The reasonable profit must depend on which party assumes the risk of the difference of actual net book value of fixed assets at the end of a contract period compared to anticipated net book value.

2.2. Revenue Risks

The revenue risks are associated with the difference between expected revenues from operation of public passenger transport and actually achieved revenues at the end of contract period. These risks may be taken either by authority or operator and in this regard there must be appropriately set a profit level of the operator. When the authority assumes the revenue risk, then a contractual relationship between the authority and the operator which sets a compensation for realized performance is based on the following formula:

$$K = (NJ + PZ) \cdot RV - V$$

where:

K – compensation of the authority for the operator
NJ – costs per unit of realized performance,
PZ – reasonable profit for the operator expressed per performance unit
RV – the realized performance,
V – revenues achieved when realizing performance.

When there are agreed final costs per unit in public service contract, which cannot be changed during a contract period, the cost risks are fully borne by the operator. The revenue risks are borne by the authority. This means that if operator's revenue is decreasing, the compensation from authority's party is increasing.

When the operator assumes the revenue risk, in the contract there is determined in addition to realized performance also absolute amount of compensation which cannot be changed during a contract period. The compensation is based on anticipated costs and revenue while changes in costs and revenue pose a risk of the operator. A part of the compensation is a reasonable profit of the operator resulting from cost and revenue risk of realized performance.

The cost risks are not usually related with interventions of public authorities (with an exception of changes in tax burden of the operator), and currently they are usually transmitted to operators. In the case of revenue risks, it is possible to define influence of public authorities on revenue risks; the risks can be divided into two groups:

- revenue risk associated with a decrease in demand - it is a risk related to the changes in number of passengers carried when providing public passenger transport. In the case that the authority bears the revenue risk, it is necessary to appropriately involve the operator in compliance with required quality because the amount of the compensation in this case does not depend on the number of passengers carried (van de Velde, Veeneman and Shipholt, 2008). In SR this risk is very significant because the demand for public passenger transport expressed in passenger-kilometres (pskm) is decreasing annually in road and railway transport.

When it comes to the revenue risk associated with a decrease in demand, it is necessary to distinguish territories in which the transport services are operated. The development of number of passengers carried depends to some extent on the interventions of public authorities which can indirectly influence the number of passengers carried through fulfilling their strategic objectives. The strategic objectives of public authorities can be divided to (Stanley and van de Velde, 2008):

- o economic - maximizing the effectiveness and efficiency of resource use (e.g. limitations of unused connections, fare increase for less used connections, taxation of passenger cars as a source of compensation for losses of public passenger transport, etc.);
- o environmental - minimizing the impact of transportation in a served area (e.g. limiting access of cars at defined time intervals in a serviced territory);
- o social - ensuring possibility of mobility for all people, particularly for vulnerable groups of passengers (lower fares for students, pensioners, etc.);
- o public - planning transport policy and other policies in a region (e.g. deployment of schools raises a demand for carriage, etc.).

- revenue risk associated with a change of passenger structure - it is the risk of revenue change because of a change of passenger structure. For example, when the selected groups of passengers (students, pensioners) travel with special fares, an increase in number of those passengers while keeping the total number of passengers causes a decrease in total revenue for providing transport services. The good solution is setting an appropriate pricing policy of transport services. However, it is important to monitor the impact of price changes on the demand, which varies considerably for particular groups of passengers (Gnap, Konečný and Poliak, 2006). In the Slovak Republic, the discounted fares known as saver tickets (half price of a full fare ticket) are for young people aged 6 to 15 and students to 26, and fares known as "other fares"[2] are for: senior citizens

[2] Decree of Office of Rail Regulation No 654/2005 lays down the scope of price regulation for railway transport and

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over 70 (€ 0.20 per every 50 km, severely disabled people (half fare travel), parents travelling to visit their physically or mentally disabled, chronically ill children nourished in special facilities in Slovakia (half fare travel). The public passenger transport fare is regulated by public authorities that decide which specific groups of passengers will be entitled to reduced fares; and, therefore, the revenue risk associated with the change in passenger structure can be classified as the risks associated with interventions by public authorities.

3. The Risk Allocation between the Contracting Parties

There are several possibilities how to allocate the risk which are based on general forms of contractual relationship between authority and operator (van de Velde, Veeneman and Shipholt, 2008):

First of all, operator bears no risk - cost and revenue risk is borne by authority that pays the economically justified costs to operator. Those costs are accounted in the end of period. This means that the risk from difference between anticipated and actual costs is borne by authority which bears also the risk from difference between anticipated and actual revenue. In this case, the level of reasonable profit of operator should relate only to numb capital during providing transport services because he bears no risk. The reasonable profit, in this case, must include, in addition to the numb capital, also a reward for assuming the cost risk.

Secondly, operator bears cost risk- the operator bears the risk from difference between anticipated and actual costs in the end of period and the authority bears the risk from difference between anticipated and actual revenue.

Thirdly, operator bears cost and revenue risk- in this case the operator bears the risk from difference between anticipated and actual costs/revenue, which are identified in the end of contract period. The authority pays only compensation which is agreed before realized performance to operator. This means that the authority bears no risk.

The analysis of the risk allocation between operator and authority in selected regions of Great Britain, Norway, Sweden, Finland, Denmark, Netherlands, Italy, USA, Australia, and New Zealand shows that in practise all the mentioned ways of the risk allocation can be found (Hensher and Wallis, 2005). For example, the risk can be also divided between contracting parties in a certain share regardless of whether there is cost or revenue risk. This can be realized in several ways: either by full allocation of complete risk to one of the parties (risk of entire difference between anticipated and actual costs/revenue is allocated to one of the parties) or sharing risk by contracting parties (a specific share of risk from difference between anticipated and actual costs/revenue, is assigned to one of the parties, e.g. each party bears the cost risk of 50%). Finally, it can be the sharing of risk between the parties, taking into account specified constraints; this represents risk-sharing proportionally up to a certain limit (e.g. the operator bears revenue risk up to limit of 500 000 € and the risk over this limit is shared between contracting parties in the same proportion – 50%).

When contracting in public interest, the authority must decide on how to allocate the risks between contracting parties (van de Velde, Veeneman and Schipholt, 2008; Wallis, Bray and Webster, 2010). The risk can have a negative impact on the result of concluding contracts and, therefore, the authority should consider several facts such as: increasing risk increases surcharge to reasonable profit; the high level of risk borne by operator can cause a risk of operator's insolvency; and the higher risk, the lower number of candidates are interested in realization of transport services.

4. Conclusions

The reasonable profit for services which are provided in public interest must be based on the risk assumed by operator. There is a methodology, not only in SR but also in other countries, on the basis of which the reasonable profit is determined as percentage mark-up on costs. But in this case, the operator is not motivated to save up the costs and it is also contrary to the policy of the European Union. Until now in area of public passenger transport, there has not been developed any procedure for reasonable profit determination which would depend on the risk assumed by operator despite the fact that some authors define the risk existing in providing transport services in the form of cost and revenue risk. The goal of this paper was to process a risk analysis on the side of costs and revenue in the conditions of Slovakia and propose possible risk allocation between authority and operator with pointing to possible consequences of the allocation. The analysis was realised based on the works published abroad. The main contribution of the article is the processing of procedure for calculating the level of reasonable profit according to risk which is assumed by operator and the way of quantifying the risk. The procedure can be applied in practice in any European Union Member State because it is in line with current EU regulations.

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price quotations of self-governing regions which determine the maximum prices for national regular bus transport when the distance from origin to final bus stop exceeds 100 km

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Possible repair methods of concrete retaining wall

Nicolas Saliba[1], Ladislav Bartuška[2]

[1]VŠTE v Českých Budějovicích, Katedra stavebnictví, Okružní 517/1, 370 01 České Budějovice, telefon: 387 842 177, e-mail: saliba@mail.vstecb.cz
[2]VŠTE v Českých Budějovicích, Katedra dopravy a logistiky, Okružní 517/1, 370 01 České Budějovice, telefon: 387 842 177, e-mail: bartuskal@mail.vstecb.cz

Abstract This document gives instruction and information about remediation of transport retaining walls. Concrete and reinforced concrete retaining walls in terms of proposal and workmanship in comparison with many other structures can be considered less demanding. Unfortunately, this fact does not apply every time and we have to solve compromise proposals for remediation. Calculation of load would also not be problematic even for a less ambitious structural engineer. Also, design principles, and most simple form should not bother anyone. The ways of remediation described in this article can be applied to other concrete structures, whether they are retaining walls and noise barriers along roads or railways.

Keywords Static and structural defects in the retaining walls for transport structures, remediation, concrete walls, causes of defects, weathering, load, the assessment of defects, waterproof concrete, examples of remediation.

JEL L99 – Industry Studies: Transportation and Utilities - Other

1. Introduction

Concrete and reinforced concrete retaining walls in terms of proposal and workmanship in comparison with many other structures can be considered less demanding. Unfortunately, this fact does not apply every time and we have to solve compromise proposals for remediation. Calculation of load would also not be problematic even for a less ambitious structural engineer. Also, design principles, and most simple form should not bother anyone.

2. The main defects of retaining walls in transport (and other) structures

The main defects frequently encountered in retaining walls are mainly:

- Excessive length of expansion joints. It should be around 15 meters and can be designed for greater lengths, but this fact mainly increases the cost of a larger horizontal reinforcement.
- The base is designed with insufficient dimensions based on low quality soil survey. When faulty design and workmanship, there are several ways of remediation, which requires higher costs and thus it may also include other negative effects.
- When calculating the active pressure there is not considered surcharge for a retaining wall, which is then reflected inter alia in the lower stability of the wall.
- Small cover to reinforcement, taking into account weather conditions. In a short time unpleasant reinforcement corrosion is manifested.
- The designer suggests lower class concrete. An object is exposed to the weather and adverse impacts from all sides. With regard to the long-standing durability of the object, higher class concrete is appropriate.
- Construction joints are not sufficient. There are numerous tools that are not being used.
- Waterproof concrete is proposed at the expense of savings of waterproofing. Concrete does not often meet this requirement and so many problems have arisen by repairing these walls - see example.
- When designing there is lack of attention paid to shrinking of concrete. This problem can be recently considered the most significant.
- On the rear obverse of the wall (when working with waterproof concrete) it is desirable to place a foil DELTA and layer of gravel, which seduces the water to the base and into the drainage.
- Special attention is not usually paid to the upper obverse of the retaining wall, which is most exposed to the outside environment - temperature, rain water, etc.

3. Interesting examples of retaining walls remediation

There are a few resolved remediation cases of retaining walls; the most interesting are listed below:

- A retaining wall at the railroad with a length of 400mm, with distances of expansion joints up to 40m, with numerous vertical cracks.
- A retaining wall of low quality concrete. By sloughing of surface layers the reinforcement with advanced corrosion was uncovered.
- A retaining wall with expansion joints with a length of 33 m from low quality concrete and insufficient reinforcement (dimensions above the base strip).
- A retaining wall made of waterproof concrete (length of 60 meters), which has numerous cracks and completely insufficient horizontal reinforcement (diameter of 8mm by 200mm). Waterproofness is not guaranteed.
- Several retaining walls in Prague with low quality construction joints and insufficient reinforcement. Various possibilities for removing gross defects.
- An improperly designed and constructed concrete wall for reducing transport noise impact with many cracks. Remediation required, inter alia, with the creation of more expansion joints.
- Retaining walls at the entrance to the underground garage. Details are presented in the next part of this contribution.

4. Remediation of retaining walls at the entrance to the underground garage - example

Retaining walls at the entrance to the underground garage were built in 2001, which in a short time after demoulding began to show cracks, the cause was to be found in the shrinkage of low quality concrete. The cross section of the wall is shown in Figure 1, and cracks on the wall at one side are shown in Figure 2. This cannot be left in its current condition and, therefore, in 2005 the remediation process started; it consisted of grouting the cracks and leaking concrete that had to be waterproof. Detail of grouting is shown in Figure 4 and porous concrete is illustrated in Figure 3. This remediation process was not too successful and cracks, of course, to a lesser extent, began to appear later.

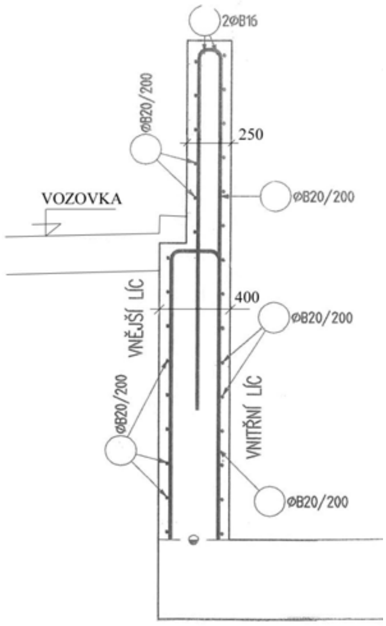

Figure 1. Cross section of a retaining wall

As particularly on the upper inclined surface more cracks were formed through which water penetrated into the walls, and on their both sides unpleasant white efflorescence appeared, possible ways of remediation were proposed.

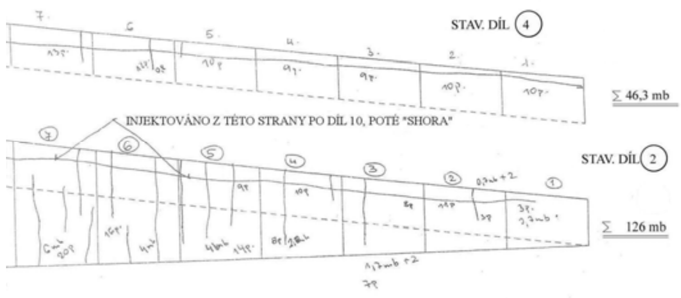

Figure 2. Technical record keeper of cracks on the internal face of the wall (cut)

Variant 1

It consists of extending transverse cracks on the upper face of the wall to the width of 12-15 mm, to a depth of cover layer, ie 20-25 mm. These gaps should then be filled with a flexible sealant (color of concrete). Remark: it is recalled that the recommended width of the cut is necessary because of volume changes when the small width of the gap is not able to exercise the flexibility of the material in a gap.

Filling the cracks will prevent water penetration into a greater depth and the creation of efflorescence on the wall sides to a depth of about one meter will be prevented. The effectiveness of this fix can last several years, but not on a long-term or permanent basis.

Variant 2

With this method it is advisable to perform grouting of current cracks of width larger than 0.3 mm with customary epoxy resin. Subsequently, on the upper face of both parapet walls the following steps should be performed:

a) Attaching the foil of a thickness of 2-3 mm (color of concrete) about 10 mm wider than the width of the wall.
b) Attachment of metallic strip of a thickness of 2 mm on the upper face of the wall with overlapping and bending on each side of 20 mm. The plate is metalized color of concrete, or otherwise modified.

In both cases the penetration of water into cracks and formation of efflorescence on the walls will be prevented.

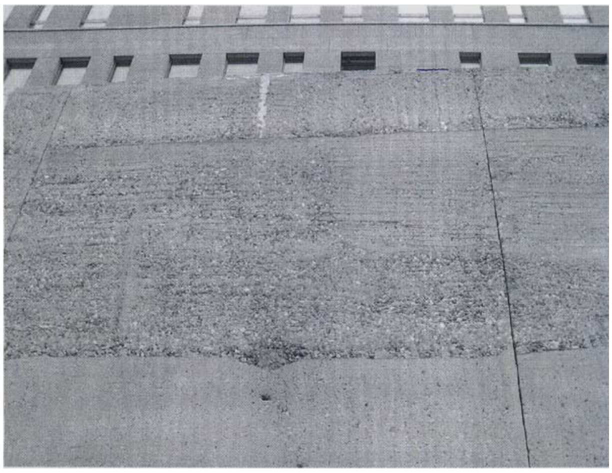

Figure 3. Low-quality waterproof concrete

Variant 3

This is a radical and final variant, comprising:

- Cutting through the parapet wall at two points, ie thirds of the length of the walls to create expansion joints at a distance of 33/3 = 11 m, and to a level of the lower wider wall.
- The elimination of the top layer of concrete to the existing reinforcement.
- The addition of transverse and longitudinal reinforcement in a degraded part.
- Concreting the missing part using non-shrinking cement. In the case of interest a new layer could be extended with the overlap of 2-5 cm with the eaves edge.
- Correction of newly formed expansion joints in cutting areas.

Variant 4

A compromise solution would also be laying the concrete slabs with a transverse gradient in quality mortar and overlap over the wall, just as it is done by common fence walls. Modification of transverse joints between prefabricated components requires special attention.

Figure 4. Grouting of low-quality concrete

Variant 5

This method consists in keeping the walls in the current state, ie., all cracks and damage. The walls and the upper face is topped with glued toughened polystyrene of a thickness of 30 mm, fitted with structural plastic net and a layer of a plaster of epoxy in a good quality and weather resistant. In other anticipated changes in volume of concrete will show cracks in a limited extent under the abovementioned cladding, which is satisfactory because defects are not visible. The core of this proposal is to create a long-lasting quality wall surface without cracks and the paint is the same color as concrete, which was the investor's wish.

5. Conclusions

The article describes several ways in which constructions can be remediated and their life can be extended. The aim of the article is to draw attention to common and quite unnecessary gross defects in projects and implementation of concrete retaining walls.

Incomprehensible is the fact that even new constructions immediately after the build require remediation. Note that not always it is worth to design the structure only for ultimate limit state and design must take into account the durability of structures. To avoid the necessity of remediation shortly after the construction of retaining structures, care must be taken primarily on their professional construction according to the static design, in compliance with the structural principles and guidelines for the implementation of concrete and reinforced concrete structures. We recommend that new structures are designed not only to ultimate limit state, but also to limit state and serviceability limit state of cracking.

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Measurement of the braking distance in dependence on the momentary vehicle weight

Branislav Šarkan[1], Lukáš Holeša[2], Peter Ivánek

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitná 1, 010 26 Žilina, Slovakia, Email: branislav.sarkan@fpedas.uniza.sk
[2] Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitná 1, 010 26 Žilina, Slovakia, Email: lukas.holesa@fpedas.uniza.sk

Abstract The braking distance is one of the most important features of the braking system of a vehicle during its operation. The distance depends on many factors related to technical part of the vehicle, road surface or the driver. This paper focuses on the examination of the impact of the momentary weight of the vehicle on its braking distance. It aims at explaining the issue through practical tests and drawing conclusions for further research and practical application in expert activities.

Keywords Braking distance, Vehicle weight, Driving tests

JEL L91 - Transportation: General

1. Introduction

When analysing a traffic accident and determining the cause of the same, one of the crucial factors can be the length of the braking distance or the determination of the braking retardation of the vehicle. The following text implies in part 2 that the weight of the vehicle does not have any impact on the length of the braking distance in the mathematical calculation based on basic physical principles. We, therefore, attempted in our paper to specify values obtained by practical measurement of the braking distance and braking retardation of passenger vehicle and values of the braking distance and braking retardation of cargo vehicle as obtained from the diploma thesis of Bc. Jakub Motl: "Impact of the momentary speed of vehicles on their braking distance“, supervised by doc. Ing. Aleš Vémola, PhD, USI Brno 2010; due to the difficulties we encountered in providing cargo vehicles for our own measurements we wanted to perform.

2. Basic physical relationships.

We are to begin with the known information that kinetic energy of a moving vehicle changes during braking to resistance; it holds that:

$$E_k = A_e \tag{1}$$

$$\frac{m.v^2}{2} = F.s_e \tag{2}$$

$$\frac{m.v^2}{2} = G.\mu.s_e \tag{3}$$

$$\frac{m.v^2}{2} = m.g.\mu.s_e \tag{4}$$

As already said, basic mathematical rules imply that m (vehicle weight) reduces itself as can be seen on both sides of the equation, then:

$$\frac{v^2}{2} = g.\mu.s_{v_e} \tag{5}$$

We used the symbol s_v as the length of the own braking distance, thus, the above relationship results in:

$$s_v = \frac{v^2}{2.g.\mu_e} \tag{5}$$

The said relationship therefore implies that the length of the braking distance does not depend on the vehicle weight. Based on our experience we can ask whether it is really true that the length of the braking distance does not depend on the total vehicle weight; our intention is to clarify this issue in the paper.

3. Methods for testing brakes of road vehicles

Braking systems of vehicles have, with regard to the road traffic safety, one of the foremost places in order of functional parts directly impacting safety of driving.

Basic requirements for vehicle brakes can be summarised as follows:

- brakes should ensure prompt and reliable stopping or slowing down at speed, status of vehicle load and inclination of driving line occurring during traffic. The braking system shall be, therefore, capable of inducing the required braking power on the perimeter of all wheels,
- the braking effect of individual vehicle wheels shall be divided to wheels so as not to disturb directional stability of the vehicle during braking,
- the braking effect shall be created also in case of increased temperature of brake components, for instance during repeated intensive braking,
- achievement of the suitable amount of controlling powers on the breaking pedal,
- achievement of the minimum delay in the start of the pressure of the braking system.

The basic division of methods of testing brakes of road vehicles is the following:

- method of outdoor driving testing,
- rolling brake test room.

Outdoor driving testing of road vehicles aimed at brakes is performed especially for the purpose of practical measurement of required values including:

- braking distance,
- braking retardation,
- braking time,
- initial braking speed,
- other (such as controlling power on the braking pedal).

We currently use under conditions of laboratory equipment of the Department of Road and Urban Transport two devices: a measuring device Correvit with evaluating unit EEP-2 and decelerometer with commercial designation XL Meter (Figure 1).

Figure 1. XL Meter.

We used the decelerometer XL Meter for driving test measurement of braking distances in dependence on the momentary vehicle weight. This is a universal accelero- or decelero-meter with alphanumeric LCD display serving for the measurement and evaluation of vehicle acceleration and condition of operational brakes, with simple operation. This decelerometer enables measurement of basic values such as braking distance, braking retardation, braking time and initial speed of braking. The capacity of performed records is 8 measurements with max. duration of recording 80 seconds with frequency of data storage 200 Hz. The time of start and end of braking is determined on the grounds of measured characteristics. The time of braking (Tbr) is calculated by the difference of the initial and final time of braking. The value of the initial vehicle speed is calculated by integration of acceleration data in the braking interval. The braking distance So is then calculated as the double integral of acceleration in the braking interval.

4. Practical measurements on a passenger vehicle

We performed measurements on a passenger vehicle on the grounds of facts as stated in part 3 of the paper. The Department of Road and Urban Transport uses the vehicle Citroen C6 (Fig. 2) for outdoor driving testing. Measurements were made on the test road, which is the landing field of the former agricultural airport in the village Rosina near Žilina. The test road surface is dry rough asphalt.

Measurement conditions:

- the vehicle has the pressure in tires in compliance with the manufacturer's recommendations,
- alternatives to measurement of a full and empty vehicle,
- marking the place of the braking start,
- initial speed of braking provided with the vehicle CC.

Figure 2. Outdoor driving test of the passenger vehicle.

The fully occupied vehicle was the condition when there were 4 more persons in addition to the driver present in the vehicle with total weight of 270kg and cargo in the baggage compartment with weight of 30 kg, i.e. the momentary vehicle weight was increased by 300 kg. The braking of the vehicle took place from the speed of 60 $km.h^{-1}$ and we performed 20 measurements for both conditions (full and empty vehicle). Detailed results of measurements are shown in Tab. 1.

Table 1. Measurement results of the passenger vehicle

n. of m.	Unloaded			
	s (m)	v (km.h^{-1})	t (s)	b (m.s^{-2})
1	19.06	60.93	2.12	8.76
2	20	61.7	2.15	9.39
3	18.8	60.83	2.11	8.49
4	17.07	59.82	1.96	9.4
5	17.61	60.24	1.99	9.31
6	17.34	59.58	1.97	9.14
7	17.01	59.8	1.98	9.35
8	18.32	61.65	2.01	9.16
9	19.56	61.1	2.17	7.79
10	17.97	60.64	2.05	8.7
11	18.48	60.38	2.08	8.62
12	18.64	60.84	2.04	9.43
13	18.73	60.69	2.18	8.65
14	19.38	61.53	2.11	9.04
15	18.56	60.89	2.11	8.94
16	17.69	60.2	1.99	9.2
17	22.3	61.33	2.41	8.14
18	17.8	59.19	2.04	8.63
19	19.28	61.34	2.14	8.26
20	16.97	58.78	1.99	8.92
average	18.53	60.57	2.08	8.87
n. of m.	Loaded			
	s (m)	v (km.h^{-1})	t (s)	b (m.s^{-2})
1	18.82	61.8	2.1	8.21
2	18	59.75	2.07	8.78
3	17.84	59.47	2.08	8.92
4	17.71	58.48	2.06	8.83
5	17.57	58.84	2.05	9.28
6	17.86	60.21	2	9.21
7	18.6	59.5	2.11	9.18
8	18.65	59.56	2.09	9.57
9	19.48	59.81	2.18	8.87
10	18.08	59.34	2.07	9.05
11	18.13	59.57	2.15	8.83
12	18	59.28	2.09	9.14
13	18.14	58.61	2.1	8.86
14	17.06	59.07	2	9.19
15	17.83	59.43	2.03	9.3
16	17.46	59.36	1.99	9.2
17	16.91	58.34	1.97	9.34
18	19.67	60.37	2.13	9.11
19	18.42	60.91	2.04	9.36
20	20.47	60.04	2.22	8.88
average	18.24	59.59	2.08	9.06

Measurement results of the loaded and unloaded passenger vehicle can be considered almost identical. Differences in the value of the braking distance are minimal.

In order to better understand the results of outdoor driving tests, braking power measurements in the rolling brake test room at the Technical Control Station /STK/ Žilina Šibenice were subsequently performed. Again, two measurements were performed, with the loaded and unloaded vehicle. The purpose of the measurement was to determine differences between braking powers. Measured values of braking powers are shown in Tab. 2.

Table 2. Measurement results of the passenger vehicle

	Unloaded		
	left (kN)	right (kN)	together (kN)
Front brake	4.1	4.49	8.59
Rear brake	2.66	2.51	5.17
Axle	6.76	7	13.76
	Loaded		
	left (kN)	right (kN)	together (kN)
Front brake	4.9	5.12	10.02
Rear brake	3.59	3.55	7.14
Axle	8.49	8.67	17.16

The passenger vehicle not loaded during the measurements in the rolling brake test room achieved the total value of braking powers on the front and rear axle 13.76 kN. This value increased after loading the vehicle to 17.16 kN. The result of this test shows that the loaded vehicle is able to induce higher braking power until the wheels are blocked. This fact can be considered the main reason why comparable results of the vehicle braking distance for both the loaded and unloaded vehicle were obtained during outdoor driving tests.

Figure 3. Passenger vehicle in the rolling brake test room

5. Practical measurements of a cargo vehicle

There is an assumption that a significantly differing situation during practical measurements of braking distances will occur upon usage of various types of road vehicles, especially if we consider the size of useful weight. It can be logically assumed that cargo vehicles with high value of usability of the useful weight will reach more significant differences in braking distances before and after loading than the passenger vehicle the useful weight of which is incomparable. The majority of useful weight of passenger vehicles is formed by passengers in the vehicle or other small cargo in the baggage compartment.

Due to the reasons specified in the introduction we used results of this measurement from the mentioned diploma thesis. The author performed practical measurements on the cargo vehicle Scania P 380. The load of the vehicle changed during measurements from the status of fully loaded (24 060 kg), partially loaded (16 980 kg) and empty vehicle (11 660 kg). 8 measurements of the braking distance were performed for each of the said conditions from the speed 35 and 55 $km.h^{-1}$. Measurement results are shown in Tab.3 for the reference speed 35 $km.h^{-1}$ and in Tab.4 for the reference speed 55 $km.h^{-1}$.

Table 3. Measurement at speed 35 $km.h^{-1}$

	Loading		
	Empty	Partial	Full
Average speed ($km.h^{-1}$)	36.61	35.36	36.79
Average braking distance (m)	7.79	8.31	10.24
Average braking time (s)	1.53	1.67	1.97
Average value of MFDD ($m.s^{-2}$)	7.35	6.58	5.7

Table 4. Measurement at speed 55 $km.h^{-1}$

	Loading		
	Empty	Partial	Full
Average speed ($km.h^{-1}$)	58.06	58.54	58.24
Average braking distance (m)	19	20.51	23.93
Average braking time (s)	2.38	2.49	2.93
Average value of MFDD ($m.s^{-2}$)	7.18	7.06	6.09

The results show that the biggest difference of the measured braking distance occurred at the speed 58 $km.h^{-1}$ of full and empty vehicle, namely almost 5 metres and the difference of the achieved braking retardation was app. $1 m.s^{-2}$.

Of course, it would be necessary to perform more driving tests and measurements, especially starting from higher initial speeds of vehicles, in order to further explain differences in the length of braking distance and braking retardation. We would probably find even bigger differences in the length of the braking distances and in achieved braking retardation. We intend to perform such measurements in the future.

6. Conclusion

These findings are important for experts from the field of road transport, because it was experimentally found that for solving traffic accidents the momentary weight of a vehicle does not have any impact on the length of the braking distance or on the value of the braking retardation. Regarding the solution of cargo vehicles traffic accidents, the momentary weight of vehicles does have impact on the length of the braking distance and on the value of braking retardation and the expert can thus already base his/her conclusions on specific measured values, for instance, of braking retardation, which are used for certain analytical solving of traffic accidents. However, we would like to repeat that it is necessary to perform further practical measurements for higher speeds of vehicles.

These findings and results make clear that the momentary weight of a vehicle does have an impact on the length of the braking distance and on the value of achieved braking retardation. However, it cannot be derived that basic physical relationships stated in the first part of paper do not apply here. The length of the braking distance and the achieved value of braking retardation depend on the value of the braking power. The value of the braking power depends on the design of brakes and on their dimensioning. The dimensioning of brakes is not a problem for passenger vehicles, but it is a clear problem for cargo vehicles and, therefore, the above said differences of length of braking distances and value of braking retardations were measured for the cargo vehicle upon the change of the momentary weight of the cargo vehicle.

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The Application of Automatic Identification Technologies by the Czech Post

Daniel Zeman[1], Petra Juránková[2], Libor Švadlenka[3]

[1]Jan Perner Transport Faculty, University of Pardubice, Pardubice, 532 10, Czech Republic
[2] Jan Perner Transport Faculty, University of Pardubice, Pardubice, 532 10, Czech Republic
[3] Jan Perner Transport Faculty, University of Pardubice, Pardubice, 532 10, Czech Republic

Abstract This article deals with the question of practical use of automatic identification technologies in postal sector, with special focus on using barcode technologies and radio frequency identification in Czech Post. After introductory section, which is aimed at description of current situation and analysis of crucial factors of choosing automatic identification technologies, there are subchapters discussing the theoretical base of both technologies, as well as their practical use in postal sector. In the part of practical application of both identification technologies is specified the basic structure of barcodes used by Czech Post and also the description of international project UNEX, which deals with the measurement of the quality aspects of selected postal products and services. Concluding part contains a brief outline of possible radio frequency identification technology application.

Keywords Automatic Identification, Barcode, Czech Post, Logistic Hub, Postal Operator, Postal Sector, Postal Service, Radio Frequency Technology

JEL L87 – Postal and Delivery Services

1. Introduction

Application of modern mobile communication devices, electronic products and services, and their consequent utilization for substitution, addition, and possible improving of traditional postal services in the last two decades resulted in a marked acceleration, improving and upgrading the overall processing of postal, express and courier shipments. However, the existence of alternative forms of communication and transmission of data, have affected the postal operators also in a negative sense, particularly by decreasing the above mentioned use of traditional postal services by private users. Falling demand for provided postal services by the current user is at least partially compensated by the increase in demand from large companies that use postal services mainly due to the wide coverage of postal networks (compared to the still limited coverage of the Internet and electronic services), or because there is lack of suitable alternatives. For these reasons, postal operators are forced to continually invest in technology and support by them provided portfolio of services, with the aim to maintain, or continuously improve the quality of the postal services, and also their level of competitiveness on the postal market.

Requirements for the provision of adequate postal services by users are reflected in the need to improve the qualitative parameters (time, speed, reliability, availability, real time tracking) less quantitative parameters which influence the process of shipment delivery (number of processed items, amount of handling processes with the postal items, number of post offices, number of postmen, available car fleet, etc.). Conversely in an effort to fully satisfy user requirements, the postal operators must equally take into account the quantitative parameters of postal operation and related technological equipment, because the processing of large volumes of mail under predetermined conditions for the shortest delivery time and the lowest error rate would not be feasible without adequate automation and clear identification.

From a technological perspective, the above mentioned identification of postal items is in practice ensured by implementing the technology of automatic identification and data capture (AIDC, which means the Automatic Identification and Data Capture). Within the AIDC we distinguish several technologies, but not all of them are suitable for identification of the postal items, or their evolution and adaptation to the conditions of the postal sector are still in the testing phase, or only partial deployment. Specific deployment is ultimately dependent on several factors, requirements, properties, or limiting characteristics of each technology.

The main aim and intention of this paper is to briefly describe the automatic identification technologies used in the postal sector, namely the Czech post. There will be also space for concise definition of the main criteria affecting operation and deployment of these technologies.

2. Main Determinants of the Choice of Automatic Identification Technology

In the present marked by the crisis, the *economic aspects* of development, implementation and operation are the decisive factors in the deployment of new technologies and systems. Each company should consider options, whether it pays to implement new technology, especially if there is an alternative that is indeed cheaper and more often used, but on the other hand, it does not provide such a wide range of application and possibilities for further development. Therefore, it is necessary to calculate not only with input costs associated with the establishment and introduction of new technologies, but also with operating costs in which are included the ongoing operating costs, maintenance costs, the cost of solving unpredictable circumstances, and also the cost of updating hardware or software.

In this situation there is possibility of outsourcing from specialist companies whose portfolio of services is oriented to the providing of overall operation and maintenance of particular technology, often from development, through testing, deployment, operation, maintenance, solving the emergency situations, updating or expansion by additional modules. This eliminates the need to operate their own departments, which should be in charge of all these tasks; the problem remains only the question of what appears to be economically more advantageous at the moment of choice. Last but not least, considering the economic aspects of implementing the new technology, it is also important to consider the extent or corporate level on which the planned technology is going to be deployed. It can be either an application of local character in one branch of the organization, deployment to multiple departments or global deployment affecting the whole network organization [12].

In a hypothetical ranking of the deciding factors, we can place at first place along with economic factors also a group of *technical aspects and rate of their performance*, that is, whether chosen technology meets requirements which we have stated to be performed. The fact, whether the application of the technology is appropriate we find by the comparison of selected factors not only in the experimental laboratory conditions, but also in the real operation, both in normal situation as well as in the increased load. The most important operational factors of the automatic identification technology used in the postal sector are:

- *The accuracy and reliability of measurement and identification* - it is primarily based on the users requirements for the accurate delivery of the required mailings, inserting of exact input data, or processing the data (for example, during manual data entry an error occurs on average with every 300^{th} postal shipment, while when using the barcode technology number of errors is reduced to one in one million). The confidence factor plays an important role in terms of maintenance when we consider whether there are any unexpected downtimes due to the technical failure or unreliability, or because of unreliability of the sensing methods used under certain conditions [4], [10].
- *The speed of sensing and identification* - the aim of the continuous development of automatic identification technologies in the postal sector, was and still is an effort to accelerate all processes related to the collection and distribution of mail, which would lead to shortening the time needed for the delivery of mail and thus to increasing the perceived quality from the perspective of customer. For the postal operators are particularly important speed of sensing and the associated parameter indicating the operational capacity of the technology; it is due to the large volume of mail handled and number of operation processed. In the postal and logistics services, we can define the work capacity of automatic identification technology according to the number of items scanned per unit of time (minute, hour, day), even if it is necessary to calculate with the human factor and the fact whether the concerned department is fully automated or not.
- *The error rate of sensing and identification* - error rate of sensing can be determined as the percentage of wrong scanned postal items / identifiers (barcodes, RFID tags, etc.) within the total number of scanned items. Causes of errors in reading are of different nature and origin, such as:
  - technical unreliability of sensing technologies, either on the sensor or on the carrier of the code
  - unsuitability of the environment in which the technology is used and its effect on signal transmission and readability
  - damage on the sensor or on the carrier of the code in such scale that will affect the readability (torn, dirty barcode, damaged RFID tag)
  - incompetence in handling with the scanning device or with the carrier of the code [4]
- *The flexibility and mobility* - they are not measurable quantities, such as accuracy, speed, capacity and error rate, but they belong to the important factors influencing the choice of appropriate technology for automatic identification. The term flexibility in this case means that the technology is multipurpose, simple to use, usable in extreme environments and conditions. Mobility is characterized by the independence of existing data, or energy networks, with the potential use of wireless data transmission (Wi-Fi, Bluetooth, satellite links, etc.), thus greatly expanding the available options for operational deployment of selected technologies.
- *The requirements on the working environment* - inadequate working conditions can have significantly negative influence to the physical principles and phenomena on which the selected AIDC technology is based, thus increasing the error rate, inaccuracy of sensing and measurement; it can restrict the devices flexibility and reduce overall suitability of using the device (creating

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conflict phenomena by the signal propagation, weak signal transmission depending on the environment, a significant influence of environment on the technical depreciation of the equipment, etc.) [4].

- *The security* - the last, but equally important place among the selected factors has the safety of the technology that can be seen from two perspectives. In terms of safety the technology in relation to human health, there have not been demonstrated negative effects of automatic identification technology to the attendant staff. On the other hand, we can speak of the safety in terms of security of information and data held when the researchers try to find different approaches how to break the security of data and information and get access to them, for the purpose of deterioration, alteration or theft [11].

3. The Technologies of Automatic Identification Used in the Postal Sector

The most important automatic identification technologies used in the postal sector are the technology of barcodes and radio frequency identification technology (RFID, which means Radio Frequency Identification). The origins of both technologies can be found within the fifties of the 20th century, so these are not new technologies, modern are rather the ideas of its various uses in the postal, express and logistics services, as useful tools for fast and safe identification of the goods, packages or shipping units. From different reasons, including, for example, the relative simplicity, economic demands, sophistication of technology, general adaptability, etc., it is more common to use the barcodes rather than radio frequency identification [7].

In the following part of the paper we will discuss brief theoretical characteristics of these technologies, their principles of operation as well as practical use in the postal sector with a focus on the specific application within the Czech Post.

3.1. Barcode

The basic operating principle of barcodes is based on the physical properties of colours in relation to the incident light, which are able to reflect or absorb. Using the optical reflection and mutually contrasting colours (black and white, possibly each other high-contrast colour combinations) arranged according to a specific algorithm, we obtain a system of lines and spaces, which are responsible for accurately encoding of information, thus numeric or alphanumeric characters. Individual lines and spaces may vary in width and they represent the system of encrypted characters, and the encoding of information into the final version is done by a specific coding table relevant to the specific type of barcode [2]. In addition to a combination of bars and spaces, the barcode contains also a numerical combination that makes it easy identification in case of mechanical damage to some parts of the code, or malfunctioning of optical sensing device where you can insert appropriate numerical combination manually. The length of numerical combination depends on the kind of code and consists of a prefix (numbering system or the international country code), manufacturer code (in the Czech Republic contractually assigned by *GS1 Czech Republic*), product code, which carries given code and check digit used to verify the correctness of the numeric string [1], [4]. In the following Figure.1 is shown an example of barcode Code 128 Set C.

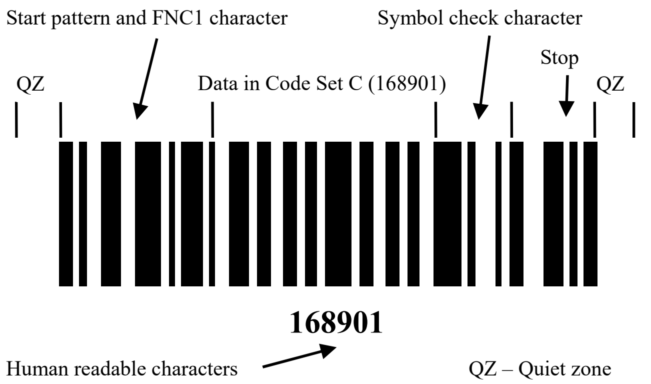

Figure 1. Example of barcode Code 128 Set C.

Nowadays, the use of barcodes is already so widespread that a normal user does not realize all the benefits that come with it. These include:

- the possibility of print in minimum cost
- cheap and reliable sensing
- high safety and effectiveness of data encoding
- international acceptance
- adaptability to use on different materials (carrier of the barcode)
- simplicity of operation and sensing [4], [10]

The technology of barcodes is not perfect and it results in considerable financial investment worldwide that are spent to the further development of barcodes, or to the research of alternative technologies of automatic identification. The main reasons of this fact are following negative aspects of using the barcodes:

- it is not possible to scan barcodes without direct visibility
- the data carriers have less damage tolerance (compared with RFID tag)
- relatively short lifespan
- smaller amount of data which can be stored in the barcode
- static character of the data (data cannot be changed or deleted and reinserted) [10]

The main reason for the further development of new solutions and barcode types is that possibilities offered by alternative technologies are not yet able to fully offset the benefits that accrue from the use of barcode technology.

3.2. The Application of Barcodes in the Postal Sector

For the labelling of postal shipments which are processed by the Czech Post, alphanumeric barcodes type Code 128 (see Figure 1), a fixed length of 13 characters coded, are standardly used. This is one-dimensional barcode with a relatively high information density [4]. It includes 107 different symbols (103 data symbols, 3 start codes, 1 stop code) and three subsets, A, B and C, which are just different ways of interpreting the data encoded by the barcode. Using the subset A or B Start code you can encode the entire ASCII character set, including control codes. With a subset C Start code you encode high density numeric data. Barcodes Code 128 can be of variable length and they require a checksum.

This code is printed on the posting label (see Figure 2), and depending on the type of shipment, the labelling is done within the enterprise or at the place of submission, thereby facilitating the process of sorting and identification of consignments. All registered consignments are usually marked by barcode at the application site. Ordinary correspondence is marked with the assigned barcode within the automatic processing based on the postal zip code and the delivery location at logistic hub (SPU). There is not assigned an element of automatic identification within the process of manual sorting.

The barcodes have important role in the system Track & Trace service, allowing customers to track the real movement of shipments through the internet. The move of the shipment identified by unique posting number (barcode) can be monitored in real time, and the service can be used for domestic or international shipments (sales packages, mail packages, insured parcels, valuable letters, standard parcels and registered mail). In terms of relevance for the postal operator, the main task of the system Track & Trace is the establishment and maintenance of the registry information obtained from the data flow between collecting logistic hubs (information about all operations carried out with the consignment from the submission, through transport to delivery), integration of this registry with the system APOST and also with the operational databases (middleware). Track & Trace system is the basic element of technology for processing and recording consignments with barcode at post offices, logistic transport nodes and post offices of exchange [3], [8].

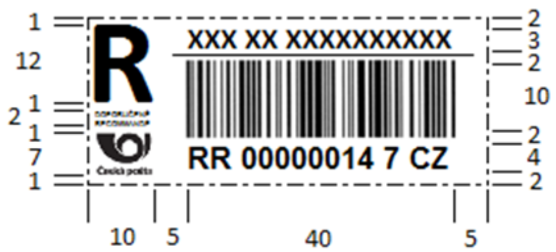

Figure 2. Technical structure of posting label used by Czech Post.

The barcode characters indicate the following information:

- *RR* - prefix for RR shipment
- *00000014* - serial number (range 1 to 99999999)
- *7* - check digit
- *CZ* - postfix (other postfixes for contractual sender: F, M, U, C - for the submitter has the barcode different structure)
- *XXX XX* - ZIP office of origin
- *XXXXXXXXXX* - name of the office of origin [3]

3.3. Radio Frequency Identification

The basic principle of radio frequency identification technology is based on transmitting a signal through electromagnetic waves, their subsequent modulation and the use of physical properties of electromagnetic waves by the propagation in free space. The source of the primary signal is a device called a reader device (so-called RFID reader or reader) which comprises a transmitter / receiver circuit with the decoder and antenna. If necessary, the reader is in some cases also equipped with its own operating system providing basic software functionality. The receiver of the emitted signal is a device called transponder (the RFID tag), which is actually an electronic memory circuit containing a silicon chip and an antenna for receiving and transmitting the signal.

In addition to RFID readers and RFID tag, every radio frequency identification system contains a third equally important component part; that is the control software (middleware) which is designed to manage, filter and analyse data obtained from a scanned tag [9]. Last but not least, the middleware provides also process control, communication with individual readers and general data processing. Communication between the reader and the tag takes place at various frequencies. Depending on radio frequency used by sensing, we can identify three main groups of radio frequency systems:

- *LF (Low Frequency):*
  - range of frequencies 125 – 135 kHz
  - characterized by the short reading distance (to 0.5 meter) and has low speed of communication
  - it is particularly suitable for reading through the liquid and partly through the metal
- *HF (High Frequency):*
  - range of frequencies 13,56 MHz
  - distance reading is usually up to 1 meter, higher communication speed than at low frequency range
  - it leads to substantially shorter detection range when reading through the liquid, or when using the tag placed on a metal substrate
- *UHF (Ultra High Frequency):*
  - range of frequencies 860 – 960 MHz
  - reading distances are about 1-6 meters, achieves high communication speed
  - suitable for situations where is it necessary to scan information from objects moving high speed (e. g. toll gate)
  - cannot read through the liquid and scanning through metal is difficult
  - different range of frequency bands within continents [5]

The main advantages of RFID technology over barcode technology are much greater quantities of stored data, as well as the possibility of manipulation with the data (change, addition, deletion, update, etc.). In addition to the above mentioned benefits, the RFID technology has greater speed scanning and sensing range, the possibility of multiple sensing, greater resistance to mechanical damage, longer

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life, the dynamic character of data held, programmability, and also eliminates the need for direct line of sight between the reader and the tag.

The disadvantages include the previously mentioned financial performance (cost per tag), less general prevalence of use in comparison with barcodes, or technical sophistication especially in terms of device compatibility, standards and protocols [5], [7], [12].

3.4. The Application of Radio Frequency Identification in the Postal Sector

The national postal operator Czech Post uses the RFID technology in the system of international performance measurement (quality) of postal operators - so called UNEX project. The system was initiated by the *International Postal Corporation* (IPC) and the main aim of this project is help the national postal operators, particularly in the area of monitoring and improving services (international letter-post items) provided to their customers. This project also has specialized coordinators, who are able to provide help to postal operators in their native language.

UNEX system is based on a network consisting of more than 4,500 volunteers in 43 participating countries, who are chosen by an independent organization *TNS Research International*. Volunteer participants have to, according to pre-established weekly schedule, send and receive "test letters", and subsequently they have to record into the central computer system the time period in which they received the letters. In this way, they can each year send and track over half a million international priority letter mail, thus providing a picture of actual geographical samples and physical characteristics of the transport process. The main emphasis is on quality aspects of mail delivery, a speed and reliability.

3.4.1. The Methodology of the UNEX System

The movement of the test letters is monitored by RFID technology. Each letter has a built-in RFID tag (carrier of the data), which enables to track where goods are situated, how fast they are delivered to a post office, where was the postal item processed. Data are sent through information systems to global IPC centre, where the system describes and analyses either progress or delays of test letter from the country of origin to the country of delivery. UNEX provides measures on both ends (the so-called end-to-end) international postal network (see Figure 3) [6].

Figure 3. The string "end-to-end" in the UNEX measurement system.

Quality measurement of postal services by UNEX system operates at three levels:

- it measures the performance between IPC member countries and cities in order to improve operating parameters of postal transport,
- it measures the performance in form of final payments (payment for postal item delivery from one postal operator to the other) connected with the quality of provided services,
- it provides data about the performance of cross-border postal streams, which are – based on postal directive of the European Union – required for annual evaluation of accumulated system efficiency.

Limits of particular quality indicators, which have to be met by postal operators participating in UNEX system, are set on basis of the revised Directive 97/67/EC of the European Parliament and of the Council on common rules for the development of the internal market of Community postal services and the improvement of quality of services. For speed indicator (D+3 period) the value is set to 85%, and for reliability indicator (D+5 period) the value is 97% of all international consignments.

Within the UNEX measurement, the average number of days required for delivery to the addressee is monitored as well. This number is indicated as D+n, where D (Day, sometimes also J as for Jour) refers to the day of the nearest collection from the time of sending or posting the consignment; therefore, for example, D+3 (J+3) means the number of days (n = 3) before final delivery to the addressee, including all phases of the consignment relocation: from collecting, sorting, national and international transport up to the actual delivery of the consignment. The method of calculating the transport period (D+n) for the date of the shipment is based on a five-day working week (from the point of view of postal operator), excluding Saturdays, Sundays and all national and regional holidays, during which the post office in the destination country is closed. In 2012, some countries involved in the UNEX system introduced delivering and processing of consignments on Saturdays, resulting in a slight change of the method of calculating the period of consignments transport. Methodology of administration and collection of the consignments can be illustrated by the following D+n performance matrix for a five-day (black) and six-day (red) working week (Figure 4).

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU
D/D	D+1/D+1	D+2/D+2	D+3/D+3	D+4/D+4	-/D+5	-/-	D+5/D+6	D+6/D+7	D+7/D+8	D+8/D+9
	D/D	D+1/D+1	D+2/D+2	D+3/D+3	-/D+4	-/-	D+4/D+5	D+5/D+6	D+6/D+7	D+7/D+8
		D/D	D+1/D+1	D+2/D+2	-/D+3	-/-	D+3/D+4	D+4/D+5	D+5/D+6	D+6/D+7
			D/D	D+1/D+1	-/D+2	-/-	D+2/D+3	D+3/D+4	D+4/D+5	D+5/D+6
				D/D	-/D+1	-/-	D+1/D+2	D+2/D+3	D+3/D+4	D+4/D+5
					D/D	-/-	D+0/D+1	D+1/D+2	D+2/D+3	D+3/D+4
						D/D	D+0/D+0	D+1/D+1	D+2/D+2	D+3/D+3

Figure 4. D + n performance matrix.

Generally accepted rule is that a consignment posted on Saturday or Sunday in the five-day variant and on Sunday in the six-day variant of the calculation is considered to be posted on Monday. Consignments posted on a public holiday or any other non-working day is considered to be a consignment posted on the following collection day.

3.4.2. The Deployment of the RFID Technology by the Czech Post

The required prerequisite for participation in the project UNEX was the installation of RFID technology implemented in 2005 at selected post offices providing foreign postal services. It was at the post offices Prague 120 and Breslau 120 (see Figure 5, marked in green). The planned extension of the implementation of RFID technology started in 2012, namely the post offices Prague 022, Brno 02 and Plzen 02 (see Figure 5, marked in blue). While in 2005, installed RFID technologies at logistic hubs Prague 120 and Breslau 120 were used to sensing and capture of the arrival/departure of test letters with RFID tags, with the introduction of RFID technology in the other three branches Czech Post will get an overview about the catchment area for logistic hubs Prague 022, Brno 02 and Plzen 02. The expanding of the monitored area allows the Czech Post to obtain more detailed information regarding the operated area with the possibility of further improving the overall quality of the transportation process, processing of mail, as well as provided services. The information obtained by monitoring may also serve as background information for the future deployment of technology of radio frequency identification within major transportation network of the Czech Post. In economic terms it is an appropriate tool to estimate additional costs needed to completion the RFID technology in the rest of the transport nodes. Red marked postal nodes in Figure 5 graphically interpret the logistic transport nodes of Czech Post, which are good candidates for future completion with the RFID technology [3], [8].

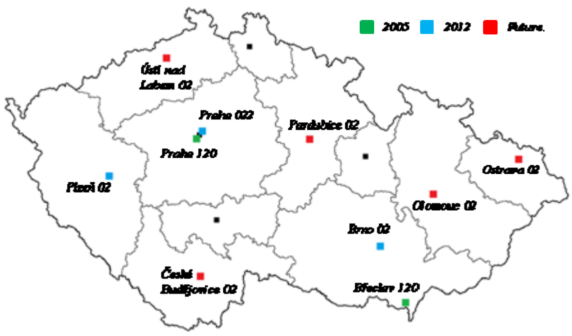

Figure 5. Graphical representation of the post offices of Czech Post, equipped with RFID technology.

With the complex deployment of radio frequency identification technology to track shipments can the Czech Post gain a competitive advantage over other postal operators, in particular by the increasing the efficiency of processes, refine the identification and registration of consignments, meeting the limits of transport deadlines, acceleration method of delivering items, to prevent of damage and loss of items. This information can be evaluated by each department management, thus they provide valuable knowledge about the functioning of the individual collecting transportation nodes, or when planning future development [12].

3.4.3. The Analysis of the Results of Czech Post in the UNEX System

The Czech Post, as the representative of the Czech Republic, participates in the international system of UNEX quality measurement since 2005, and it has always fulfilled the limits of each quality criteria, as we can see on Figure 6 (the performance of the Czech Post is marked blue).

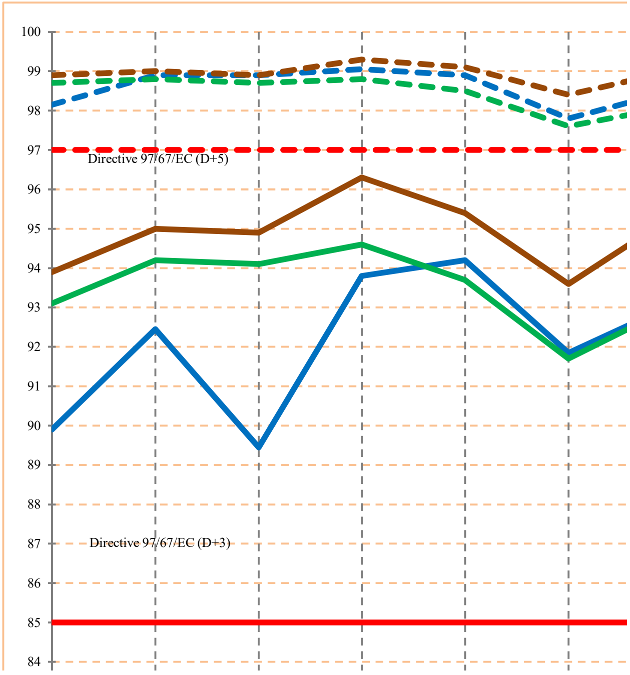

Figure 6. The comparison of measurements results by the UNEX system in the years 2005 - 2012.

Based on the analysis performed, we can conclude that the average results of reliability indicators (D+5) reflect total values of the extended UNEX29, or UNEX34/35 system (marked green), as well as the results of the original number of countries involved in the system, so called UNEX18 (marked brown); on the other hand, when talking about the speed indicator (D+3), we can observe significant deviations, especially in the results from the period of 2007 – 2009, and also from 2012. While the average results of the UNEX34/35 (93.1%, that is +0.1% compared to 2011 and +1.4% compared to 2010) and the UNEX18 (95.6%, that is +0.3% compared to 2011 and +2.0% compared to 2010) have an increasing tendency, so the average results of the Czech Post for the 2012 on the input and output declined by -0.85% compared to 2011, while the speed indicator increased by +1.2% between 2010 and 2011.

Despite this, there is still apparent high quality level of delivering by the Czech Post, especially when comparing specific values of annual results, where the results of the Czech Post were as follows: the speed indicator (D+3) reached the final average values 91.85% in 2010 (difference of +0.15% compared to UNEX34/35 and -1.75% compared to UNEX18), 93.5% in 2011 (+0.05% compared to UNEX34/35 and -2.25% compared to UNEX18) and 92.2% in 2012 (-0.9% compared to UNEX34/35 and -3.4% compared to UNEX18). Within the scope of the reliability indicator

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(D+5), average final values were 97.8% in 2010 (difference of +0.2% compared to UNEX34/35 and -0.6% compared to UNEX18), 98.5% in 2011 (+0.4% compared to UNEX34/35 and -0.5% compared to UNEX18) and 98.65% for 2012 (compared to UNEX34/35 +0.25% and -0.45% compared to UNEX18).

4. Conclusions

Nowadays barcodes play an essential role in the identification and registration of postal items. In view of the increase in the number of processed postal items, increasing quality requirements for provided postal services, as well as the need of establishing an effective system for records of transport units, there are assumptions that despite the constant technical development, the technology of barcode will not have sufficient functionality to ensure the future needs of the postal sector. It would be appropriate to use an alternative solution based on the radio frequency identification technology, which offers a greater range of options and features. In terms of global deployment, the situation is such that current financial and technical requirements rank this technology only to the position of laboratory scale technologies or partial tool utilized concurrently with the barcode technologies.

The experience gained by the research and experimental implementation in the conditions of the national postal operators constantly expand knowledge base and thus they create assumptions for further development and practical deployment of radio frequency identification technology in the mass scale. In the conditions of the Czech Post, it is mainly about involving in UNEX project which is focused on quality measurement in relation to the international transport of mail, as well as in retrofitting of the other postal transport hubs with radio frequency identification technologies. The results obtained by measuring with the technology of radio frequency identification provide the postal operators with valuable tools which allow them to find an appropriate solution for simplification and optimization of the processes of handling and transport of postal items.

As we could see in several past years, Czech Post is able to meet the requirements set by the Directive of the European Parliament and of the Council 97/67/EC. The trend and expanding utilization of RFID technology will continue to improve the quality of postal services, eliminate errors and bottlenecks in the processes of postal operations and they will progressively evaluate existing infrastructure not only in relation to international as well as domestic transportation of mail.

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