TRAFFIC ACCIDENTAS INFORMATION SYSTEM AND RISK CRASH EVALUATION

Jiri Stodola

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University of Defence in Brno, Faculty of Military Technology,
PS 13, K 252, 612 00 Brno, Czech Republic
Tel/fax: +420 973 442 278, E-mail: jiri.stodola@unob.cz

ABSTRACT
This article analyses the traffic accident rate on roads and highways and possibilities of risk evaluation related to traffic accident occurrence based on factors that were the causes of accidents. A new term – risk of traffic accident occurrence is a product of probability of accident occurrence and its impacts. The results are presented by way of example that uses selected statistical data of the Czech Republic traffic accident rate between 1993 - 2001. The article provides a brief methodological procedure of evaluation of the traffic accident rate using the risk of traffic accident occurrence.

KEYWORDS
Traffic Accident, Risk Factor, Road Traffic Safety, Traffic Accident Consequence, Road Traffic Risk and Safety Evaluation

1. INTRODUCTION

Recently, the safety of road traffic has become a very serious problem for nearly all countries. A growing density of the traffic causes an increasing amount of accidents associated with heavy losses of property and injuries or fatalities. That is way national and international authorities pay an exceptional attention to this problem and try to mitigate the negative trends in the time development of safety of road traffic, for example by modifications of traffic regulations. To be rational and effective, the measures taken by the authorities have to result from a detailed analysis of the causes of accidents. For these reason usually the authorities in the developed countries maintain the national accident databases that gather the information on the consequences of each road accident.

2. TRAFFIC ACCIDENT STATISTICS

Data from accident databases enable to carry out the required analyses and establish the trends of the traffic safety. An analysis of time development of absolute or relative number of accidents and their consequences is the most common way of evaluation of the trends of the traffic safety. Examples of such a kind of evaluation for the Czech Republic are presented in tab.1 – 4, and fig.1 - 3. The time development of number of accidents with a certain cause or number of injuries, fatalities and amount of property damages associated with this certain kind of accident is beyond any despite useful indicator of development of safety, but sometimes the results of the above-mentioned analysis can be quite controversial. A certain weakness of this system is the fact that it employs absolute numbers that prevent comparison between the individual periods of month/day/year, causes, etc., and inaccuracy due to changes resulting from individual data changes. Substantial disadvantage of this system consists in a non-existence of a measure of severity, or acceptability of the traffic accident impacts. That is why it is not possible to determine whether the traffic accident is or is not socially acceptable, or, it is at least satisfactory.

3. RISK, AND DEGREE OF RISK

The given evaluation obviously lacks a common feature of risk level that consists in:

- Simultaneous consideration of features (risk factors) of each traffic accident,
- Probability of a certain traffic accident occurrence,
- Appropriate expression (evaluation) of traffic accident consequences,

- etc.

Table 1: Accidents and their consequences in the Czech Republic in the last 10 years

Year	Number of accidents	Number of fatalities	Number of severe injuries	Number of slight injuries	Damage (millions of €)
1993	152,157	1,355	5,629	26,821	93.4
1994	156,242	1,473	6,232	29,590	133.2
1995	175,520	1,384	6,298	30,866	152.4
1996	201,697	1,386	6,621	31,296	189.2
1997	198,431	1,411	6,632	30,155	186.9
1998	210,138	1,204	6,152	29,225	213.6
1999	225,690	1,322	6,093	28,747	223.4
2000	211,516	1,336	5,525	27,063	221.7
2001	185,666	1,219	5,493	28,297	257.6
2002	190,718	1,314	5,492	29,013	277.9

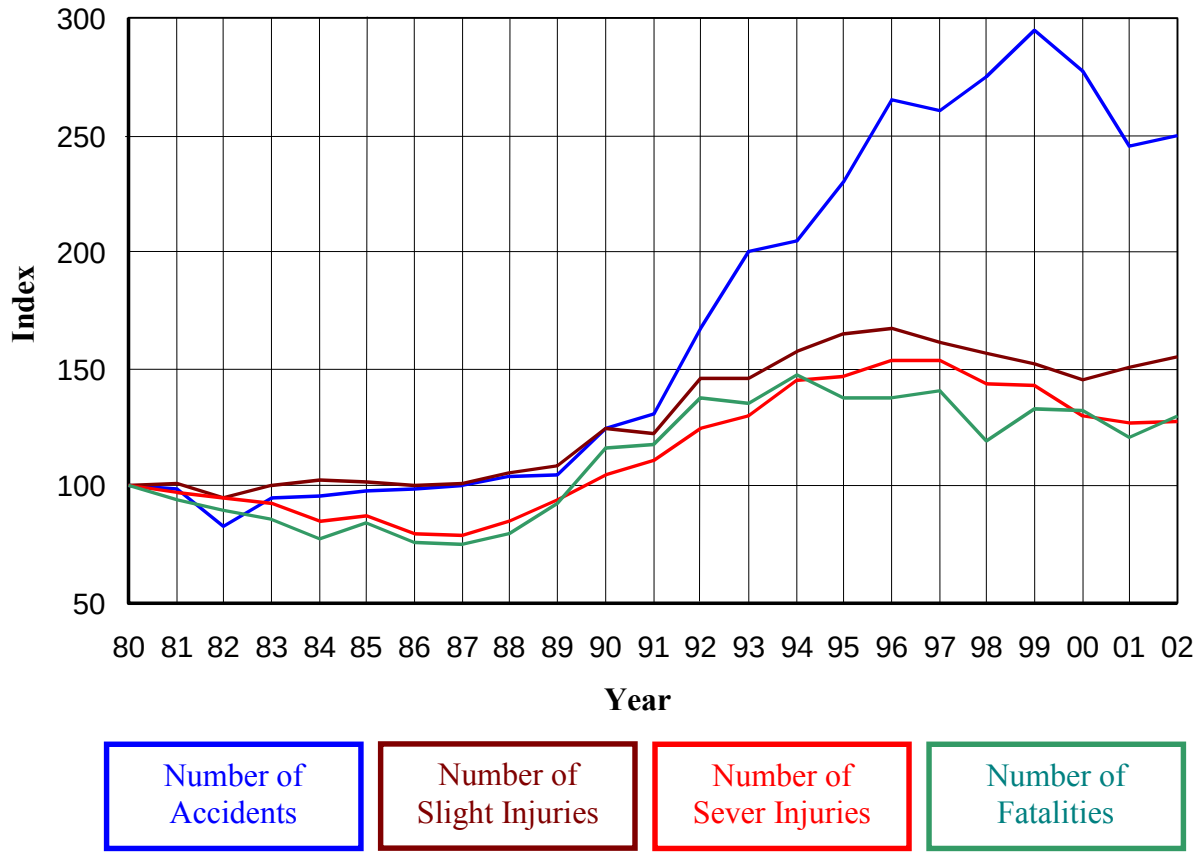

Figure 1: Statistics of accidents in the Czech Republic

NUMBER RATIO OF ACCIDENTS

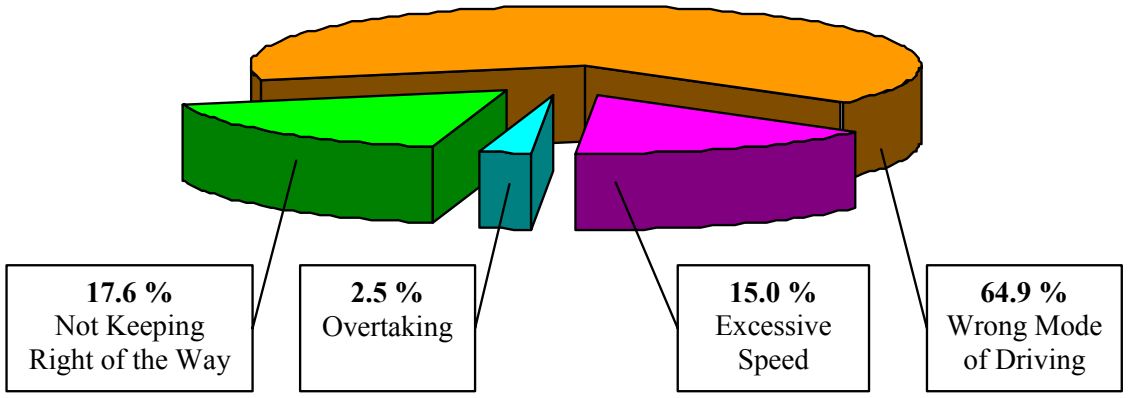

Figure 2: Main causes of accidents of drivers

Table 2: Magnitude of accidents caused by engine displacement

Car engine displacement year 2002	Participation in number of accidents (in %)	Fatalities		Difference in number of fatalities (in comparison with year 2001)	Magnitude of accidents (Fatalities per 1,000 accidents)
		Numb	%		
Up to 1 liter	4.8	49	5.6	-3	8.0
1.1 – 1.4 l	44.8	354	40.6	37	6.3
1.5 – 1.9 l	30.8	276	31.7	9	7.1
2 - 3 l	15.7	188	21.6	26	9.5
Over 3 l	0.7	4	0.5	-7	4.5
Undiscovered	3.2	0	0.0	-2	0.0

Table 3: Places of accident

Places of accidents year 2002	Number of accidents	Number of fatalities	Number of severe injuries	Number of slight injuries	Damage (millions of €)
In Municipality	139,345	501	2,886	17,689	171.5
Index (year 2000 = 100%)	103.0	110.1	102.9	103.7	108.2
Off Municipality	51,373	813	2,606	11,324	106.3
Index (year 2000 = 100%)	102.1	106.4	96.9	100.8	107.3
Motor Way	4,293	51	120	525	15.9
Index (year 2000 = 100%)	102.8	127.5	114.3	107.8	109.5

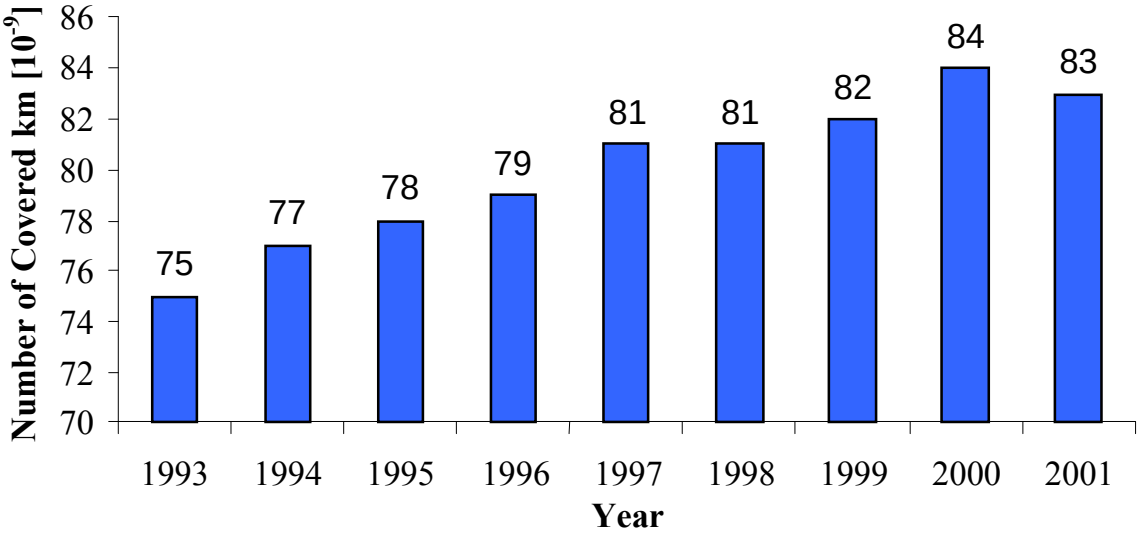

Figure 3: Annual number of kilometers covered by all vehicles in Czech Republic in one year

Table 4: Evolution of number of accidents, fatalities and injures in the last 10 years

Year	Number of accidents	Number of fatalities	Fatalities per 1 accident	Number of severe injures	Number of severe injures per 1 accident	Number of slight injures	Number of slight injures per 1 accident
			10^{-3}		10^{-3}		10^{-3}
2002	190,718	1,314	6.89	5,492	28.8	29,013	152.13
2001	185,666	1,219	6.57	5,493	29.59	28,297	152.41
2000	211,516	1,336	6.32	5,525	26.12	27,063	127.95
1999	225,690	1,322	5.86	6,093	27.00	28,747	127.37
1998	210,138	1,202	5.72	6,152	29.28	29,225	139.08
1997	198,431	1,411	7.11	6,632	33.42	30,155	151.97
1996	201,697	1,386	6.87	6,621	32.83	31,296	155.16
1995	175,520	1,384	7.89	6,298	35.88	30,866	175.85
1994	156,242	1,473	9.43	6,232	39.89	29,540	189.07
1993	152,157	1,355	8.91	5,629	36.99	26,821	176.27

It is evident that there exists a more complex evaluation using the institute of risk *R* in the following form:

$$R = P \times C,$$

where *R* … risk of traffic accident, *P* … probability of traffic accident occurrence, *C* … consequence of traffic accident.

A risk defined in this way is a non-dimensional parameter and it provides mutual comparison of various groups of causes of traffic accidents, their characteristics and it also enables mutual comparison of individual types of traffic accidents. To enumerate the risk of traffic accident according to this equation it is necessary to quantify probability of accident occurrence P and consequences of traffic accident C. Possibilities of that are presented in paragraph 4 and 5.

The second way in which it is possible to evaluate risks associated with traffic accident is usage of rate of accidents that represent probability of accident per one kilometer with respect to fatalities, severe injuries, and slight injuries. In the case of evaluation of damage caused by accident it is suitable to use co

called specific damage that represents average damage per one kilometer. Equations for rate of accident and specific damage enumeration are presented in table 5.

Table 5: Equations for evaluation of rate of accidents and specific damage

Rate of accidents	Rate of fatalities	Rate of severe injuries	Rate of slight injuries	Specific damage
$R_A = \frac{N_\Sigma}{D_C}$	$R_F = \frac{N_F}{D_C}$	$R_{SEI} = \frac{N_{IS}}{D_C}$	$R_{SLI} = \frac{N_{ISL}}{D_C}$	$R_D = \frac{N_D}{D_C}$

where D_C … distance covered in the Czech Republic in calendar year, N_F … number of fatalities in calendar year, N_{IS} … number of severely injured people in calendar year, N_{ISL} … number of slightly injured people in calendar year, N_D … sum of damages.

Next possibility of risk evaluation is usage of so called degree of risk D_R that can be expressed by the following equation:

$$D_R = \frac{C_{Ai} N_\Sigma}{C_{A\Sigma} N_i} \ ,$$

where C_{Ai} … number of consequences by given cause of accident, $C_{A\Sigma}$ … number of consequences by all accidents, N_Σ … number of all accidents, N_i … number of accidents by given cause of accident.

Degree of risk D_R indicates how many times the given cause of accident is more risky than statistically significant average cause of an accident.

4. PROBABILITY OF TRAFFIC ACCIDENT OCCURRENCE

Probability of traffic accident occurrence encompasses a complete system of phenomena and, using a classical definition, equals to the probability share of frequency of specific type of traffic accident and total amount of traffic accidents in the period under survey. Probability of traffic accident P can be expressed in the following equation:

$$P = \frac{N_i}{N_\Sigma} \ ,$$

where N_i … number of accidents of evaluated i-th type in calendar year , N_Σ … total number of accidents in calendar year.

To determine this probability we can use sufficient credible data in the statistics of the traffic accident rate. Classical probability defined in this way shall be valid exactly in two-status model and its constraints rest in a necessity or assumption of similar possibilities of occurrence of random events – e.g. types of traffic accident. In practice, it may often happen that random event– type of traffic accident is not definite and may not happen anyway. There are possibilities of more generally approach to a probability, in practice - an axiomatic, or, in our case - statistic approaches are used.

5. IMPACT OF TRAFFIC ACCIDENT

The impact can be considered a measure of the traffic accident severity. It is a significant part of magnitude of risk. Here exists a general inversion principle based on the fact that an accident with a high level of probability of occurrence, but with non-serious impacts has also a low level of risk rate. And vice versa, an accident even very improbable but with serious impacts is considered as highly risky. To date, no

transport standards provide a unique method of evaluation of the impacts of traffic accidents. In general, the impact of traffic accident can be established using two methods:

1) Use of expert methods when a severity level can be attributed to each accident as a relative value of accident impact with a meaning of weight, e.g., within the range of values from the interval: $0 \le C \le 1$, with possible interpretation: with no impacts $C\,min \to 0$, catastrophic impacts $C\,max \to 1$.

2) Use of international standards when severity of single categories of accidents is established by a scale - Minor, Major, Critical, Catastrophic, with exact definition of severity of individual categories. In some domains (e.g. aviation, etc.) for each category there exists a maximum value of socially acceptable probability of accident occurrence (Table 6).

3) Expressed impact is a tool with similar meaning as probability; to assess the impact of traffic accident it is possible to use a probability when the traffic accident impact is expressed, for example, by the number of persons killed at the type of traffic accident examined against the total number of persons killed in all accidents in the period under survey. Thus, a severity of a given type of traffic accident if „weighted" relative to other accidents by the weight of number of persons killed, or by other „weight", e.g., a property damage as a proportion of the magnitude of resulting property damage of the participants of the accident at the type of traffic accident relative to the total property damage of the participants of all traffic accidents in the period under survey.

Table 6: Hazard Severity Categories

Description	Category	Definition
Catastrophic	I	Death and/or vehicle loss.
Critical	II	Severe injury, and/or major vehicle damage.
Marginal (major)	III	Minor injury, and/or minor vehicle damage.
Negligible (minor)	IV	Less than minor injury, and/or vehicle damage.

6. EXAMPLE OF APPLICATION

Some results of calculation are given in table 7 and figure 4. Figure 5 show forecast of number of fatalities in the course of accidents per one million inhabitants and compare the Czech Republic and Great Britain, the Netherlands and Sweden.

Resulting from statistical data the rate of accident, fatalities, severe and slight injuries, specific damages, and degree of risk were evaluated. From results presented it is evident that the most risky factors in the Czech Republic are as follows:

- hitting the oncoming vehicle during overtaking,
- riding a motorcycle,
- pedestrian on the road,
- excessive speed.

Resulting from the analysis there can be stated that are the following most hazardous factors: wrong overtaking, higher than permissible driving speed, riding a motorcycle, and pedestrian behavior. Analyses showed that low level of alcohol in blood does not significantly increase the traffic accident risk.

Table 7: Rate of accidents, fatalities, injuries, and specific damage

Year	Rate of				Specific damage
	Accidents	Fatalities	Severe injuries	Slight injuries	
	$10^{-6} \cdot km^{-1}$	$10^{-8} \cdot km^{-1}$	$10^{-8} \cdot km^{-1}$	$10^{-7} \cdot km^{-1}$	$€ \cdot km^{-1}$
2002	2.3	1.6	6.6	3.5	0.0034
2001	2.2	1.5	6.6	3.4	0.0031
2000	2.5	1.6	6.6	3.2	0.0026
1999	2.8	1.6	7.4	3.5	0.0027
1998	2.6	1.5	7.6	3.6	0.0026
1997	2.4	1.7	8.2	3.7	0.0023
1996	2.6	1.8	8.4	4.0	0.0024
1995	2.3	1.8	8.1	4.0	0.0019
1994	2.0	1.9	8.1	3.8	0.0018
1993	2.0	1.8	7.5	3.6	0.0012

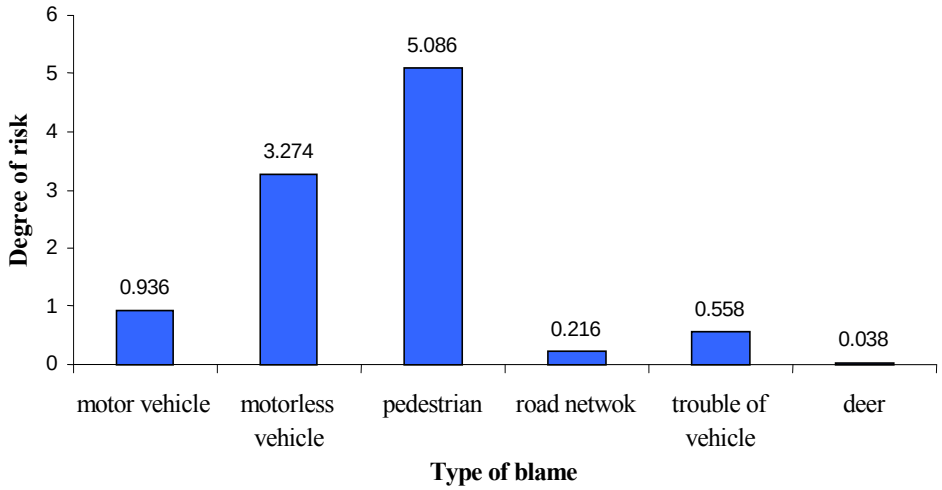

Fig. 4: Degree of risk due to blame

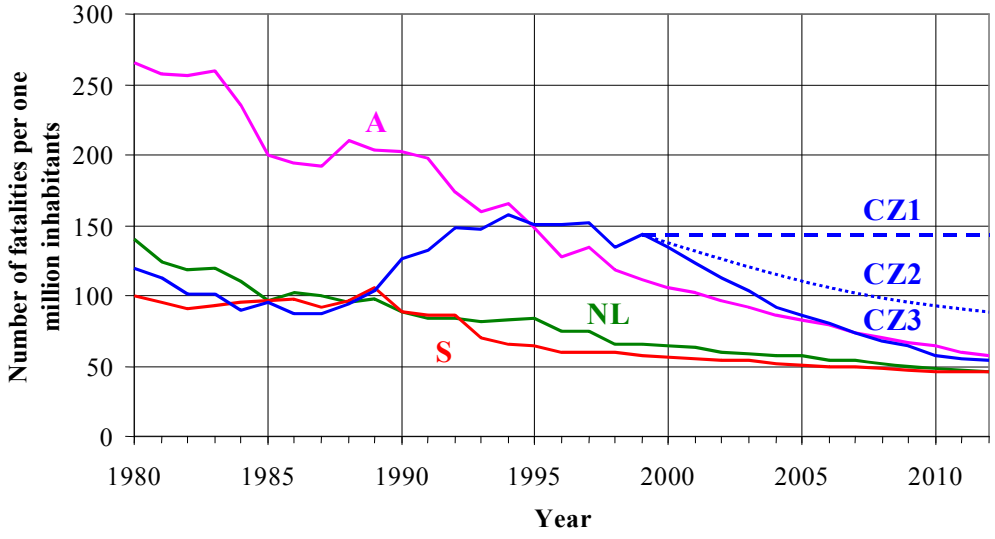

Figure 5: Forecast of number of fatalities in the course of accidents per one million inhabitants

Description of Figure 5:

A - Great Britain,
NL - the Netherlands
S - Sweden
CZ1 - Zero variant is the extrapolation of accident frequency development as in progress in the last seven years
CZ3 - Desirable variant, i. e., the accident level in the Czech Republic striving for the situation in the developed EU countries in the real-time horizon.
CZ2 - Hypothetical variant expresses the compromise between two above mentioned variants.

7. CONCLUSION

The Police of the Czech Republic maintain annual detailed statistics of the traffic accidents in the form of summary numbers and figure surveys divided by various criteria. This system provides important information that may serve as the grounds for creation of new and effective preventive measures. However, this information system does not use the institute of risk in the road traffic. And at the same time it is evident that trends in development of risk provide relatively objective and complex information to solve these traffic accidents as serious all-society phenomena. It refers mainly to the causes and consequences of traffic accidents and influence of various factors that determine the traffic accident rate.

Described methodology defines selected terms as objective tools for the systems analysis of causes and impacts of the traffic accidents. Risk of traffic accident rate is a non-dimensional parameter that can enable comparison of various effects and circumstances otherwise incommensurable. The advantage is that we can use existing statistical surveys and alternatively evaluate the safety of the road traffic. A certain disadvantage is the fact that in road traffic field there are no generally binding criteria of social or individual acceptability of the magnitude of risk related to the traffic accident. That is why the information system of the traffic accident rate cannot be used to establish whether the Czech Republic traffic accident rate is at an acceptable level, or whether it is necessary to reduce it.

REFERENCES

[1] CHUDOBA, J.: Determining of Probability of Car Accident by Conveyance of Car. Project. University of Liberec. 31 pages . 2002
[2] HAJEK, M.: Solution of problems verbal communication between participants of road traffic by risk situations in traffic. Technical university Ostrava, 2003 (76 pages)
[3] Czech Traffic Police Force.: Statistics of the Traffic Accident Rate in the CR, Set of Documents from 1993 to 2002.1, 1, Ministry of Interior, Praha, 1993 – 2002
[4] VINTR, Z.-HOLUB, R.-VALA, M.: A Risk-based Evaluation of Safety Development in Road Traffic. In: Probabilistic Safety Assessment and Management (PSAM 6) – Proceedings of 6th International Conference on Probabilistic Safety Assessment and Management. Oxford: Elsevier Science, p 493 – 498, 2002. ISBN 0-08-044122-X
[5] STODOLA, J.: Risk of Traffic Accident and Possibilities of its Evaluation. Žilina, ISBN 80-8070-121-0 (pages 127 – 130) 2004
[6] STODOLA, J.: Safety of Traffic of Motor Vehicles. Military Technical Magazine. Nr 6. Praha, 1982.s (in Czech)
[7] STODOLA, J.: For Active Safety of Automobiles. Military Technical Magazine. Nr 4. Praha, 1987 (in Czech)
[8] STODOLA, J.-VINTR, Z: Traffic Accident Information System and Possibilities of Risk Crash Evaluation. Book of Abstracts of World Automotive Congress FISITA. STA Barcelona Depósito legal: B-26597-04, 2004. (Page 412)