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SAFETY RANKING OF THE LITHUANIAN ROAD NETWORK OF NATIONAL SIGNIFICANCE

Vilma Jasiūnienė[1]✉, Donatas Čygas[2], Kornelija Ratkevičiūtė[3], Harri Peltola[4]

[1, 2, 3]*Dept of Roads, Vilnius Gediminas Technical University, Saulėtekio al.11, 10223 Vilnius, Lithuania*
[4]*VTT Technical Research Centre of Finland, Vuorimiehentie 3, Espoo, Finland, P.O. Box 1000, 02044 VTT*
E-mails: [1]vilma.jasiuniene@vgtu.lt; [2]dcyg@vgtu.lt; [3]kornelija.ratkeviciute@vgtu.lt; [4]Harri.Peltola@vtt.fi

Abstract. The Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on Road Infrastructure Safety Management requires that the Member States shall establish and implement the network safety ranking. Safety performance of existing roads should be increased by targeting investments to the highest accident concentration sections and (or) to the road sections or crossings with the highest accident reduction potential. Road network safety management is applied within the road network in operation covering the selection of traffic safety improvement measures in optimal locations, evaluation of the safety effects and implementing the measures. The article describes the method for selecting and prioritising road sections which have higher than the average accident saving potential in each road category. When selecting road sections for treatment, a potential reduction of accident costs shall be taken into consideration. Road sections in each category are studied and classified by the factors related to road safety, such as the number of accidents, traffic flow and road characteristics. The article describes how the procedure of the road network safety ranking and the ranking of high accident concentration sections is implemented in Lithuania and propose further steps.

Keywords: road safety, road network safety ranking, ranking of high accident concentration sections, homogenous road sections, junctions, accident rate.

1. Introduction

Improvement of road traffic safety in Lithuania as well as other EU Member States still remains a priority field of transport development. Road accidents cause not only large moral but also economic losses. Analysis made by Elvik (2000) showed that losses due to road accidents make 1–2% of GDP.

Traffic safety largely depends on human, vehicles and road infrastructure (Elvik 2011; Grislis 2010; Orfila *et al.* 2010; Prentkovskis *et al.* 2010; Nævestad, Bjørnskau 2012; Schulze, Koßmann 2010; Valiūnas *et al.* 2011). Road infrastructure has a great effect on the accident risk but also to the severity of the accidents. Engineering solutions of roads can protect people from injuries in accidents but they even modify people's behaviour, which can have a great effect in preventing accidents.

In 2008, the European Parliament and the Council adopted the *Directive 2008/96/EC on Road Infrastructure Safety Management* which defines four procedures for the road infrastructure safety management:

– road safety audit;
– road safety inspection;
– road safety impact assessment;
– road network safety ranking and ranking of high accident concentration sections.

According to the European Commission the implementation of the *Directive 2008/96/EB* has the potential of saving 600 lives and avoiding 7000 serious injuries every year across the EU on the TEN-T network only.

In 2011, Lithuania prepared the *National Traffic Safety Development Program* for 2011–2017. The program defines the targets reaching of which would help to reduce the number of accidents and the number of traffic participants injured and killed on roads. The strategic objective of this program – improve traffic safety situation so that by the number of killed traffic participants per 1 million population in Lithuania in no more than the average of the 10 EU states showing the best results in this field (or no more than 60 people killed/1 million population). This objective will be implemented based on the following priorities:

– safe behaviour of traffic participants;
– safe roads;
– safe vehicles;
– speedy and high quality first-aid to traffic participants;
– modern information technologies.

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Network safety ranking is a method for identifying, analysing and classifying sections of the existing road network according to their potential for safety development and reduction of the number and severity of accidents on those sections. When selecting road sections for the analysis of the network safety ranking a potential to reduce the number of accidents is taken into consideration. Road sections are classified into separate categories, i.e. the roads of national significance are divided into homogenous sections (based on road category, speed limit, traffic volume and composition, similar road environment, etc.). Road sections of each category are studied and classified by the factors related to road safety, such as the number of accidents, traffic flow and traffic type. For the purpose of network safety ranking a priority list is made of all-category road sections where with the help of infrastructure improvements good results are expected.

Ranking of high accident concentration sections – is a method to identify, analyse and rank sections of the road network which have been in operation for more than three to five years. Identification of road sections with a high accident concentration takes into account the existing traffic volume per unit of road length or intersection, traffic composition and data on fatal and injury accidents.

Procedures defined by above definitions are interrelated and called the Safety Ranking and Management of the Road Network in Operation.

According to the *Directive 2008/96/EB* "network safety ranking" means a method for identifying, analysing and classifying parts of the existing road network according to their potential for safety development and accident cost savings. Two main objectives of this procedure can be distinguised:

- to identify and analyse the most dangerous road sections in order to more precisely target the traffic safety funds and to obtain the best possible result – reduction of accidents and their victims at the lowest possible cost;
- to assess all sections of the road network and to compare them according to their accident potential. This means to identify road sections where a potential number of road accidents is higher than in other similar sections.

Effective work with the black spots and high accident concentration sections leads to their elimination in time and network safety management becomes the main reactive activity of traffic safety. In practice this can be seen as transition from remedial and retrospective considerations to preventive and prospective way of working.

2. Methodology for road network safety ranking

A central question in relation to application of network safety ranking is how the road system should be divided into a smaller road sections and how long these sections should be. Sørensen and Elvik (2008) propose to use the following principles.

Section based principles. In the first principle, the road system is divided into sections that are homogeneous with regard to selected traffic and road design parameters that have significant influence on the number of accidents.

Point based principles. The second principle is a point based principle, where intersections, towns or other "points" are used as division points.

Accident based principles. The third principle is based on registered accidents in the identification period. Either there has to be a certain number of accidents on each road section or there has to be a uniform accident concentration or pattern on each road section.

Combination. The last principle is to combine the previously described principles.

An obvious opportunity is to combine the first two principles. The two principles differ a lot from each other, but in practice, they will result in more or less the same division and can therefore advantageously be combined. The reason that the two principles approximately give the same result is that major changes in road design and traffic obviously coincide with larger intersections and towns. To ensure reliable identifications and a potential for reducing the number of accidents the first two principles can be combined with the third principle that each road section has to have a certain number of accidents (Lynam *et al.* 2003a; 2003b). It is recommended that the road and traffic based division principles are used. The argument is that these principles can be used together with the model based identification method, where it is essential to have homogeneous road sections for the estimation of the general expected number of accidents. In addition, the advantage is that the principles more or less will result in the same division of the road system for different time periods, which make it possible to compare the accident level for different time periods for each road section. Finally, the advantage of the point based principle is that it gives a rational, easy and natural division (Sørensen, Elvik 2008).

In spring 2011, the international *BALTRIS* project was started to be implemented the specific objective of which is to develop tools and build capacity/competence for a better safety management of road infrastructure in the Baltic Sea Region. The project focuses on the exchange of experiences, knowledge and joint development of road infrastructure safety management procedures. *BALTRIS* is led by the Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania and the project partners are: Lithuanian Road Administration, Estonian Road Administration, Swedish Transport Administration, Vilnius Gediminas Technical University, Tallinn University of Technology, Lund University and Riga Technical University (Laurinavičius *et al.* 2012).

During the *BALTRIS* project a comprehensive review of investigations in different countries in the field of network safety ranking was carried out, the exchange of the best practice was performed and recommendations

were given for the implementation of this procedure defined in the *Directive 2008/96/EC* (Laurinavičius *et al.* 2012).

Procedures for the road network safety and high accident concentration sections ranking can be divided into 5 stages (Table 1):

Stage 1. Data collection. Data collection is a very important part of the implementation of network safety ranking. The collected data is as follows:

- *accidents* – location of the accident, accident type, date and hour of accident, accident severity, including number of fatalities and injured persons, alcohol level, data on the vehicles involved (type, age, country, safety equipment if any, data of last periodical technical check according to applicable legislation), road surface and weather conditions etc.;
- *traffic volume* – annual average daily traffic, proportion of light and heavy vehicles;
- *road parameters* – road status or function, road significant (type), road category, cross section including number of lanes, lane width, shoulder and the presence of bicycle lanes and side strips, possibility for oncoming traffic, speed limit, lightning, markings, alignment, roadside obstacles, number and design of intersections and access roads, junction type including signalling;
- *the surrounding environment* – rural or urban area).

Stage 2. Definition of road groups and junction groups. The groups and subgroups of road sections are defined by 4 criteria. First criterion – road type and category. Based on this criterion the whole road network is divided into 4 groups: motorway, main roads, national and regional roads; urban roads. Second criterion – cross-section. Based on this criterion the roads are divided into subgroups: road with median and roads of different width of the carriageway without median. Third criterion – speed limit. Based on this criterion the subgroups are divided into smaller subgroups according to the speed limit, i.e. 50 km/h; 70 km/h; 80 km/h; 90 km/h; 100 km/h; 110 km/h; 130 km/h. Fourth criterion – traffic volume. Based on this criterion the subgroups are divided into smaller subgroups according to the different traffic volume.

The groups defined by the first criterion are divided into groups by the second criterion and so on. Having made the division by all criteria the final number of groups is obtained.

The groups and subgroups of junctions are defined by 3 criteria. First criterion – junction type. Based on this criterion the junctions are divided into groups: level crossing T, level crossing X and grade separate crossing.

Second criterion – road type. Based on this criterion the junctions are divided depending on which road according to its significance the main road of the junction belongs to.

Third criterion: traffic volume. This criteria evlauates a proportion of vehicles entering the junction from the minor road from the total amount of vehicles entering the junction.

Table 1. Typical stages in road network safety and high accident concentration sections ranking

Stage	Explication
1. Data collection	Collection of data on roads, traffic and accidents
2. Definition	Definition of road groups and junction groups
3. Dividing	Dividing the road network into homogenous road sections and junctions
4. Identification	Road network safety ranking and identification of hazourds road sections
5. Analysis	In office analysis of hazourds road sections and junctions and on-site observatiowns of road-user behaviour

Road sections and junctions are divided into the groups based on their road and traffic data. The general idea is to build up the groups so that they describe as well as possible the variation of accident risk and accident severity.

The authors of this article were able to use very simple accident prediction models by assuming a constant injury accident rate and constant severity of accidents in each group. Severity means the number of killed persons per 100 injury accidents.

By combining the results from the accident prediction model with the accident history it became possible to make reliable estimates of expected numbers of accidents and fatalities.

This information could be used in identifying dangerous road locations. Additionally, it could be used when evaluating the safety effects of different measures in various locations. In this way, there is a possibility to create a priority list for road sections where good results are expected with the help of infrastructure improvements. And it is also possible to evaluate the effect of road improvements on those locations.

3. Road network safety management in Lithuania

Based on the given recommendations the specialists of Road Department of Vilnius Gediminas Technical University in partnership with the State Enterprise Transport and Road Research Institute and Finnish Technical Research Centre VTT carried out the safety ranking of the road network of national significance of Lithuania.

The roads of Lithuania according to their capacity, social and economic significance are divided into roads of national and local significance.

The Law on Roads of the Republic of Lithuania, adopted in 1995, the roads of national significance divides into:

1) Main roads. These are the main Lithuanian roads or their extensions – carriageways of streets with the highest traffic volumes. They comprise all

roads of national significance included into the European international road network;

2) National roads. They comprise part of the main road network. These are roads or their extensions – carriageways of streets with high traffic volumes connecting the centres of territorial administrative units of the Republic of Lithuania, as well as transit and tourist traffic;
3) Regional roads. These are roads which are used to meet the communication needs of legal or natural persons operating on the territories of territorial administrative units of the Republic of Lithuania, and connecting urban and rural residential locations with the main road network.

Based on data of 1 January 2010, provided by the *Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania*, the road network of national significance totalled to 21 268.4 km of roads, of which:

– Main roads – 1738.5 km;
– National roads – 4939.3 km;
– Regional roads – 14 590.6 km.

In order to divide road network into homogenous road sections the 2006–2010 data on road accidents, traffic volume, road parameters and the surrounding environment was collected. Data of the Lithuanian Road Information System *LAKIS* was collected into 16 data sets: 1 – cross-sections of roads, 2 – junctions, 3 – railway crossings, 4 – high accident concentration road sections and black spots, 5 – road signs, 6 – fatal and injury accidents of 2006–2010 (accidents at junctions are given separately), 7 – illuminated road sections, 8 – speed measuring equipment, 9 – pedestrian paths, 10 – protective fences from people and wild animals, 11 – road sections with the installed guardrail systems, 12 – technical categories of roads, 13 – average annual daily traffic on roads; 14 – average annual daily traffic at junctions, 15 – speed restrictions on road sections, 16 – accidents at junctions.

Based on the mentioned data the road network of Lithuania was divided separately into groups of roads and junctions.

3.1. Dividing the road network into homogeneous road sections and junctions

The groups of road sections were defined by the criteria described in section 2: road significance; cross-section of road; speed restrictions and traffic volume. Based on the above criteria 34 homogenous road groups were formed (Fig. 1).

Based on the scheme presented in Fig. 1 the Lithuanian network of the roads of national significance was divided into 13 254 homogenous road sections, the average length of one homogenous section being 2.31 km. The largest group of homogenous road sections is the group No. 3 which comprises national and regional roads, as well as gravel roads. The total length of the group No. 3 is 16 266.99 km, the roads are divided into 7770 separate homogenous road sections the average length of which is 2.06 km. The average annual daily traffic of this group of roads is the lowest compared to the other road groups – 2951 vehicles/day (vpd). Data on homogenous road sections is given in Table 1.

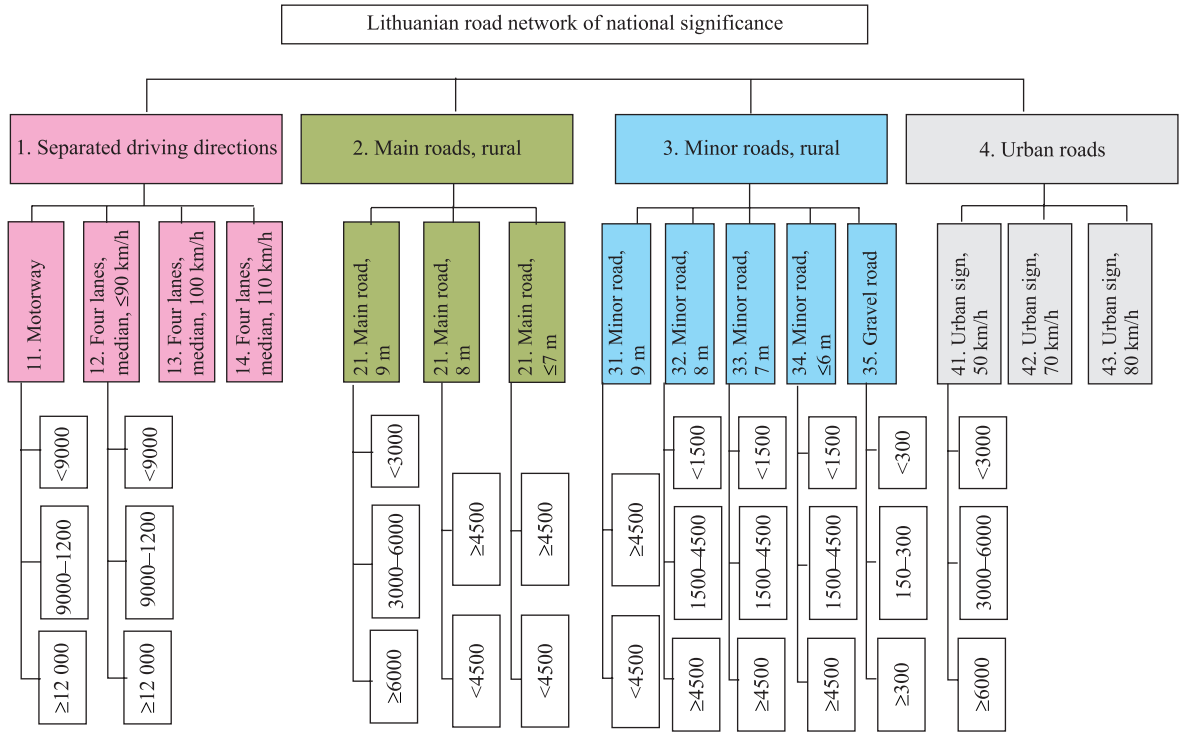

Fig. 1. The scheme on the division of road sections into groups and subgroups by AADT in vpd

Table 2. Main data on groups and subgroups of homogenous road sections

Subgroup	Subgroup *AADT*, vpd	Road length, km	The number of homogenous road sections	The average length of homogenous road sections, km	*AADT*, vpd	Proportion of heavy traffic from the total *AADT*, %
1. Separated driving directions						
111. Motorway	< 9000	160.01	23	6.96	7856	15.0
112. Motorway	9000–12000	92.34	14	6.60	10053	17.3
113. Motorway	≥ 12000	59.11	16	3.69	17637	13.0
121. Four lanes, median ≤ 90 km/h	< 9000	40.00	36	1.11	2060	10.2
122. Four lanes, median, ≤ 90 km/h	9000–12000	57.40	19	3.02	10548	7.0
123. Four lanes, median, ≤ 90 km/h	≥ 12000	52.70	29	1.82	19861	14.6
130. Four lanes, median, 100 km/h		59.24	17	3.48	21240	15.2
140. Four lanes, median, 110 km/h		14.05	3	4.68	19042	16.0
Total:		**534.85**	**157**	**3.92**	**13537.13**	**13.54**
2. Main roads, rural						
211. Main road, 9 m	< 3000	103.14	43	2.40	2238	17.6
212. Main road, 9 m	3000–6000	381.32	113	3.37	4475	14.8
213. Main road, 9 m	≥ 6000	244.51	95	2.57	8600	23.0
221. Main road, 8 m	< 4500	269.07	85	3.17	2862	15.0
222. Main road, 8 m	≥ 4500	39.22	27	1.45	6842	14.2
231. Main road, ≤ 7 m	< 4500	45.98	36	1.28	2975	15.3
232. Main road, ≤ 7 m	≥ 4500	37.83	27	1.40	6396	11.6
Total:		**1121.07**	**426**	**2.23**	**4912.57**	**15.93**
3. Minor roads, rural						
311. Minor roads, 9 m	< 4500	173.44	182	2.12	4010	26.8
312. Minor roads, 9 m	≥ 4500	89.93	43	2,02	7385	11.8
321. Minor roads, 8 m	< 1500	232.27	166	1.40	802	11.9
322. Minor roads, 8 m	1500–4500	598.04	238	2.51	2616	12.2
323. Minor roads, 8 m	≥ 4500	98.52	49	2.01	6116	9.2
331. Minor roads, 7 m	< 1500	2054.54	1119	1.84	579	12.2
332. Minor roads, 7 m	1500–4500	752.46	303	2.48	2476	11.1
333. Minor roads, 7 m	≥ 4500	97.11	65	1.49	6552	9.2
341. Minor roads, ≤ 6 m	< 1500	5242.27	3116	1.68	364	11.1
342. Minor roads, ≤ 6 m	1500–4500	610.57	265	2.30	2376	10.7
343. Minor roads, ≤ 6 m	≥ 4500	14.70	16	0.92	7226	8.5
351. Gravel roads	< 150	3633.82	1245	2.92	86	10.9
352. Gravel roads	150–300	2015.21	662	3.04	206	11.7
353. Gravel roads	≥ 300	654.11	301	2.17	518	11.6
Total:		**16266.99**	**7770**	**2.06**	**2950.86**	**12.06**
4. Urban roads						
411. Urban sign, 50 km/h	< 3000	3067.83	4568	0.67	559	1.1
412. Urban sign, 50 km/h	3000–6000	174.09	222	0.78	4114	10.6
413. Urban sign, 50 km/h	≥ 6000	82.30	100	0.82	8616	7.8
420. Urban sign, 70 km/h		3.99	4	0.99	23502	14.0
430. Urban sign, 80 km/h		12.42	7	1.77	30371	14.6
Total:		3340.63	4901	1.01	13432.4	9.62
TOTAL:		**21263.54**	**13254**	**2.31**	**8708.24**	**12.79**

The groups and subgroups of junctions were determined based on three criteria: type of junction, road significance and traffic distribution at the junction (i.e. a proportion of vehicles entering the junction from the minor road from the total amount of vehicles entering the junction).

Based on the mentioned criteria 14 homogenous groups were determined (Fig. 2). Table 2 gives the groups and subgroups of junctions determined by the criteria described in section 2.

Table 3. The number of homogenous sections of junctions

Junctions group	Subgroup of the junctions	The number of homogenous road sections
1.T – junctions	11. Main road	100
	12. Main road	47
	13. Main road	25
	21. Minor road	266
	22. Minor road	265
	23. Minor road	195
2. X – junctions	11. Main road	60
	12. Main road	47
	13. Main road	40
	21. Minor road	38
	22. Minor road	84
	23. M inor road	199
3. Grade-separated junctions	1. Local region	37
	2. Highway auth.	51
Total:		**1454**

3.2. Lithuanian road network safety ranking

Having accomplished the division of Lithuanian road network into homogenous road sections and junctions, based on the groups of road sections and junctions given in subsection 3.1, the road network safety ranking was carried out. Road sections and junctions get into the group of road sections and the group of junctions with their own accident history. To distinguish the road network safety levels it is necessary to determine the total accident level in each road group or junction group, i.e. to calculate the accident rate (*AR*) in each road or junction group. After calculating the accident rate the accident severity shall be taken into consideration. For road links the accident rate AR shows the number of fatal or injury accidents per vehicle mileage (often expressed as accidents/100 million vehicle kilometres). The accident rate is calculated by Eq:

$$AR_i = \frac{A_i 10^8}{365 L_i ADT_i m},$$

where: A_i – the number of accidents during 5 years on a homogenous road section; L_i – the length of a homogenous road section, km; $AADT_i$ – average annual daily traffic on a homogenous road section, vpd; m – the number of years, 5 years.

For junctions the accident rate is calculated respectively, however, the rate is calculated per millions of vehicles entering the junction. Thus, instead of *NL* (Eq (1)), the number of vehicles entering the junction is used (calculated by *AADT* on the legs of the studied junction, vpd).

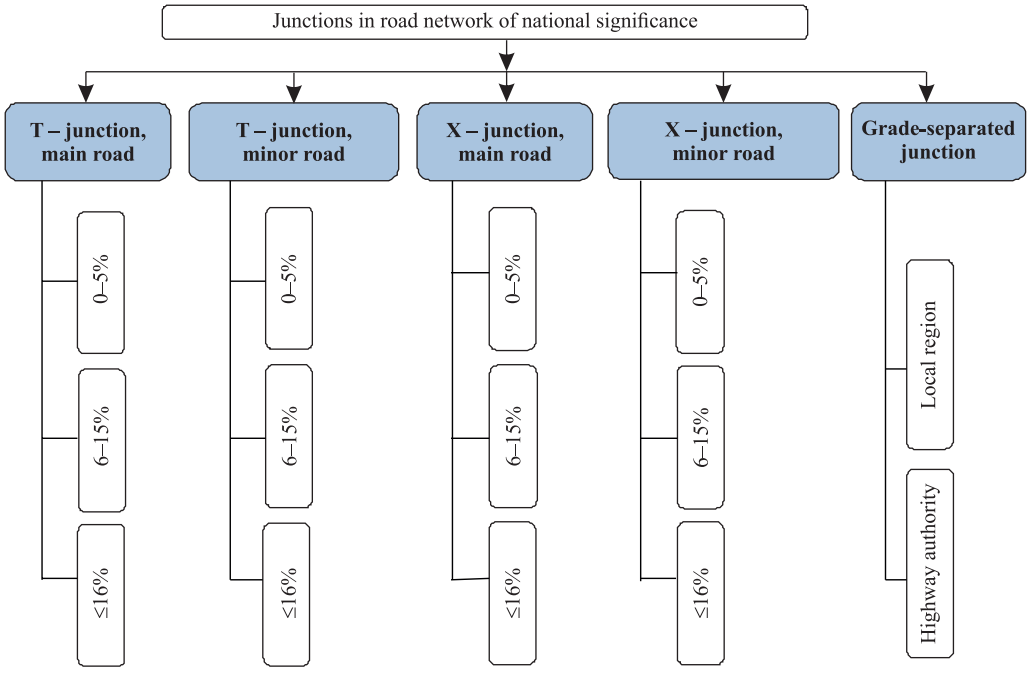

Fig. 2. The scheme on the division of junctions into groups and subgroups (a proportion of vehicles entering the junction from the minor road from the total amount of vehicles entering the junction)

After implementation of this stage the current network safety level was obtained in each road group or junction group. The average accident rate of the groups of roads or junctions allows us to determine the safety level of the group within the road network, i.e. from the total road network to distinguish the groups of roads and junctions having the highest numbers of accidents in relation to driven kilometres (or arriving vehicles in the case of crossings).

When defining road group safety levels the highest average accident rate was determined in the subgroup "Gravel roads" of the group No. 3 (Fig. 3). This subgroup contains 2208 homogenous road sections the length of which is 6303.14 km, i.e. this subgroup makes 30% of the total length of the roads of national significance. The average accident rate of this subgroup amounts to even 39.23, whereas, the average accident rate of all the roads of national significance is 15.56. This could be explained by the fact that the road sections of this subgroup represent a prevailingly low traffic volume, low road standards and low amount of enforcement.

When defining junction group safety levels, the largest average accident rate was determined at four-leg at grade junctions – 16.64, whereas, the average accident rate of the whole junctions is 12.80. The four-leg at grade junctions make 32% of the total number of junctions on the roads of national significance. The lowest accident rate was determined in the group of grade-separated junctions – 4.65. A histogram on the average accident rate of the groups of junctions is given in (Fig. 4).

After this phase, hazardous road sections are identified in terms of the high expected numbers of accidents. For this purpose the average accident risks were used as simple accident prediction models (Elvik 2007, 2008; Peltola *et al.* 2012; Sørensen, Elvik 2008).

By combining modelled accident number with the accident history the authors of this article received the estimates of accidents to be expected in the future with no measures. Additionally, utilising average severity figures, the fatality estimates were even received. These empirical Bayesian estimates are as reliable as possible, so they are a good basis for locating the most dangerous road locations and estimate the effect of safety measures on those locations.

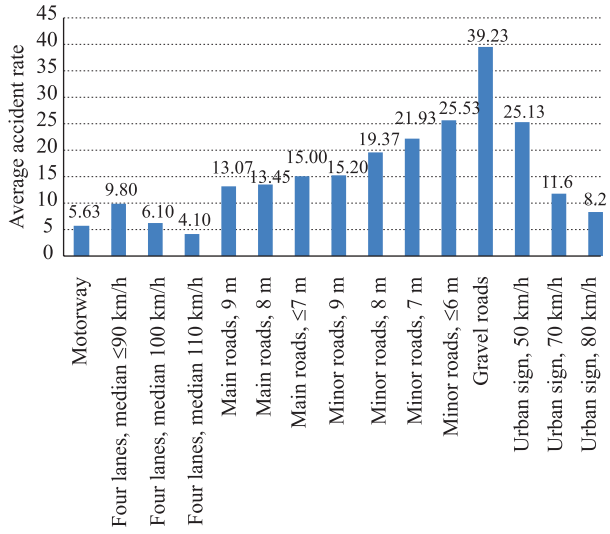

Fig. 3. The average accident rate of the road groups (data of 2006–2010)

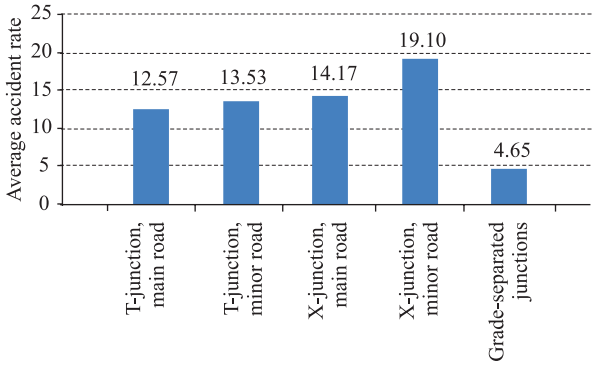

Fig. 4. The average accident rate of the groups of junctions (data of 2006–2010)

4. Conclusions

Under restricted financial investments to roads, it is necessary to ensure that the traffic safety improvement measures are implemented on the most dangerous road sections and on those road sections where it is possible with the min costs to achieve the max reduction in accident number. For this purpose, the road network is divided into homogenous road sections and the most dangerous sections safety shall be determined.

The division of road network into homogenous road sections allows to determine and rank road sections where different traffic safety measures will give highest accident reductions.

The division of road network into homogenous road sections is useful for developing mathematical accident models for a particular road section and to forecasting the number of accidents on it.

Safety ranking of the Lithuanian road network of national significance was carried out according to the section based and point based principles.

Road sections, situated between the junctions, were divided according to the section based principle. Using 2006–2010 data on road network 4 large groups of homogenous road sections were defined. Based on certain criteria, these were further divided into 34 subgroups of homogenous road sections. The road network was divided into 13 254 homogenous road sections.

When defining road network safety levels the highest average accident rate was determined in the subgroup "Gravel roads". This subgroup represents 30% of the total length of the roads of national significance. Taking this into consideration, institutions responsible for the road network safety management must pay a special attention to

improving traffic safety on gravel roads. Considering the low traffic volumes, the measures on these roads should be very cheap. Respectively one should consider even more expensive measures on roads having hign expected accident and fatality densities.

The roads of national significance contain 1454 junctions, which according to the point based principle were divided into 3 large groups of homogenous junctions which based on certain criteria were further divided into 14 subgroups of homogenous junctions.

When defining road network safety levels at junctions, the largest average accident rate was determined at four-leg at grade junctions which make 32% of the total number of junctions on the roads of national significance. Avoiding four-leg crossings and building them into two three-leg crossings, round abouts or level crossings should be considered from the safety reasons. The lowest accident rate was determined in the group of grade-separated junctions.

The created expected accident and fatality figues allow determining the most dangerous sections and crossing from each road group. Systematic review of those dangerous locations should be done and safety measures defined for them based on expected safety benefits easily available using the developed analysis procedures.

Acknowledgements

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References

Elvik, R. 2011. A Framework for a Critical Assessment of the Quality of Epidemiological Studies of Driver Health and Accident Risk, *Accident Analysis and Prevention* 43(6): 2047–2052. http://dx.doi.org/10.1016/j.aap.2011.05.024

Elvik, R. 2000. How Much Do Road Accidents Cost the National Economy? *Accident Analysis and Prevention* 32(6): 849–851. http://dx.doi.org/10.1016/S0001-4575(00)00015-4

Elvik, R. 2008. A Survey of Operational Definitions of Hazardous Road Locations in Some European Countries, *Accident Analysis and Prevention* 40(6): 1830–1835. http://dx.doi.org/10.1016/j.aap.2008.08.001

Elvik, R. 2007. *State-of-the-Art Approaches to Road Accident Black Spot Management and Safety Analysis of Road Networks.* Report 883. Institute of transport Economics, Oslo.

Grislis, A. 2010. Longer Combination Vehicles and Road Safety, *Transport* 25(3): 336–343. http://dx.doi.org/10.3846/transport.2010.41

Laurinavičius, A.; Grigonis, V.; Ušpalytė-Vitkūnienė, R.; Ratkevičiūtė, K.; Čygaitė, L.; Skrodenis, E.; Antov, D.; Smirnovs, J.; Bobrovaitė-Jurkonė, B. 2012. Policy Instruments for Managing EU Road Safety Targets: Road Safety Impact Assessment, *The Baltic Journal of Road and Bridge Engineering* 7(1): 60–67. http://dx.doi.org/10.3846/bjrbe.2012.09

Lynam, D.; Sutch, T.; Broughton, J.; Lawson, S. D. 2003a. The European Road Assessment Programme – Completing the Pilot Phase – 2001 & 2002 – Benchmarking the Safety of Roads, TEC, May 2003, 168–172.

Lynam, D.; Sutch, T.; Broughton, J.; Lawson, S. D. 2003b. *European Road Assessment Programme.* Pilot Phase Technical Report, EuroRAP. Available from Internet: http://www.eurorap.org/library/pdfs/pilot_technical_report.pdf

Nævestad, T.-O.; Bjørnskau, T. 2012. How Can the Safety Culture Perspective be Applied to Road Traffic? *Transport Reviews: A Transnational Transdisciplinary Journal* 32(2): 139–154. http://dx.doi.org/10.1080/01441647.2011.628131

Orfila, O.; Coiret, A.; Do, M.T.; Mammar, S. 2010. Modeling of Dynamic Vehicle–Road Interactions for Safety-Related Road Evaluation, *Accident Analysis and Prevention* 42(6): 1736–1743. http://dx.doi.org/10.1016/j.aap.2010.04.014

Peltola, H.; Rajamäki, R.; Luoma, J. 2012. Tools Needed for Enhancing Transferability of Cost-Effective Road Safety Measures. *Transportation Research Arena*, Greece (in press).

Prentkovskis, O.; Sokolovskij, E.; Bartulis, V. 2010. Investigating Traffic Accidents: A Collision of Two Motor Vehicles, *Transport* 25(2): 105–115. http://dx.doi.org/10.3846/transport.2010.14

Schulze, H.; Koßmann, I. 2010. The Role of Safety Research in Road Safety Management, *Safety Science* 48(9): 1160–1166. http://dx.doi.org/10.1016/j.ssci.2009.12.009

Sørensen, M.; Elvik, R. 2008. *Black Spot Management and Safety Analysis of Road Networks – Best Practice Guidelines and Implementations Steps* [cited 16 August, 2011]. Available from Internet: https://www.toi.no/article19577-29.html

Valiūnas, V.; Pečeliūnas, R.; Nagurnas, S.; Žuraulis, V.; Kemzūraitė, K.; Subačius, R.; Lazauskas, J. 2011. The Improvement Conception of Drivers Training and Examination System in Lithuania, *Transport* 26(2): 224–231. http://dx.doi.org/10.3846/16484142.2011.592216

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