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General Trends of Accident Rate in Vilnius City when Implementing Transport Humanization and Forming the Functionally Integrated Urbanistic Structures

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Abstract. The paper concerns the present situation of road safety in Vilnius City, the capital of Lithuania of road safety in Vilnius City, the capital of Lithuania. Vilnius has the largest number of vehicles and the largets level of car ownership in Lithuania. The detailed analysis and audit of accidents in Vilnius City enabled to determine general trends of accident rate and the black spots, to estimate the effect of measures implemented and their general trends, to identify street sections and intersections with the highest accident concentration. The number of fatal and injury accidents in Vilnius City has been considerably decreasing since 2007 (1029 accidents). In 2015, 596 accidents occurred where 18 road users were killed and 671 were injured. In 2015, compared to 2014, the number of fatal and injury accidents in Vilnius decreased by 7.17 %, the number of people killed – by 31.38 % and of people injured – by 5.36 %.

Keywords: road safety, traffic safety, accidents, the black spots, creating pedestrians and traffic calmed zones, collision with pedestrians.

Conference topic: Sustainable urban development.

Introduction

The detailed analysis and audit of accidents in Vilnius City enabled to determine general trends of accident rate and the black spots, to estimate the effect of measures implemented and their general trends, to identify street sections and intersections with the highest accident concentration (Ministry of Transport and Communications 2015).

The number of fatal and injury accidents in Vilnius City has been considerably decreasing since 2007 (1029 accidents). In 2015, 596 accidents occurred where 18 road users were killed and 671 were injured. In 2015, compared to 2014, the number of fatal and injury accidents in Vilnius decreased by 7.17 %, the number of people killed – by 31.38% and of people injured – by 5.36% (Lithuanian Republic Parliament 2013).

In 2015, accident losses in Vilnius City due to killed and injured people amounted to EUR 44.73 million. In Lithuanian cities and settlements the number of road accidents and their victims is twice as much as on rural roads, however at present Lithuania has no institution that would take an active part in analysing accident situation on city streets and giving recommendations to improve current situation.

The road safety improvement measures are oriented towards rural roads where accident causes are sufficiently clear: speeding, inobservance of safe distance between vehicles, dangerous overtaking manoeuvres. In urban areas accident causes are more complicated and subtle influenced by the environment of urban structures, high-volume of vehicles and pedestrians, improper transport infrastructure and road user behaviour in complicated situations. Today, the technical urban safety measures often reduce capacity of streets and intersections, create jams, increase journey time (Lazda, Smirnovs 2009).

Humanization of Vilnius City transport is only starting now by creating pedestrian and traffic calmed zones, promoting bicycle traffic and gradually building cycle tracks, setting public transport priority with the required infrastructure, reducing car mobility in the city centre.

Analysis of accident rate in Vilnius city

Development of the urban structures favourable to road safety has been started – the functionally integrated structures are planned aimed to reducing the need for transport mobility.

The detailed analysis of accidents in the territory of Vilnius City is one of measures to increase safety of all road users. The analysis and audit carried out enabled to determine general trends of accident rate and the black spots, to identify the effect of measures implemented and their general trends, to identify street sections and intersections with the highest accident concentration.

Compared to the European Union member-states, situation in Lithuania still remains rather complicated. Knowing a high level of car ownership and motorization in these countries, it is sufficiently clear that a high level of accident rate is determined not by the level of car ownership but by a common culture of road users and the specific traffic conditions (Russo *et al.* 2014).

Positive trends in the decrease of fatal and injury accidents are favourable to Vilnius City. In 2015, the number of people killed on Vilnius streets per 1 million inhabitants was 33 and it is more than twice (2.5 times) lower than in Lithuania (in 2015 – 84.0).

The number of fatal and injury accidents in Vilnius has been considerably decreasing since 2007. Later, the number of accidents slightly increased and has decreased again in recent years. Compared to the indices of Lithuania, it is obvious that situation in Vilnius City is more favourable since all the indices are better: the number of accidents and their victims in Vilnius was decreasing when the number of people killed in Lithuania was increasing. In 2015, compared to 2014, the number of fatal and injury accidents in Vilnius decreased by 0.93 times, of people killed – by 0.67 times, of people injured – by 0.95 times. (Table 1)

Table 1. Dynamics in the number of accidents and their victims in Lithuania and Vilnius

Year	**Vilnius City**			**The Republic of Lithuania**		
	Accidents	Killed	Injured	Accidents	Killed	Injured
1980	822	44	713	6192	836	4673
1990	460	70	499	5135	1001	6558
2000	1019	56	1214	5807	641	6960
2001	1058	54	1245	5972	706	7103
2002	964	53	1068	6141	697	7427
2003	985	59	1155	5963	709	7263
2004	1199	55	1386	6372	751	7877
2005	1228	53	1458	6771	773	8466
2006	996	45	1168	6658	760	8334
2007	1029	67	1182	6474	739	8075
2008	734	42	843	4987	498	5940
2009	510	30	551	3827	370	4459
2010	520	22	579	3530	299	4230
2011	593	25	668	3312	296	3919
2012	617	25	680	3392	302	3952
2013	766	29	871	3418	258	4040
2014	642	27	709	3244	265	3757
2015	596	18	671	3161	241	3777
Difference between 2014 and 2015	–46	–9	–38	–83	–24	20

Note: The number of killed in road accidents within 30 days and the number of injured having applied the reduction coefficient (1.173).
Source: Data of the Lithuanian Road Police Service

In Vilnius City the accident losses due to people killed and injured in 2014 amounted to 1.95x27+0.1776x708 = LTL 178.4 million or EUR 51.7 million. In 2015, the accident losses made 0.565 x 18 + 0.0515 x 671 = EUR 44.73 million.

In the preparation of the National Road Safety Development Program an active participation of the Ministry of Transport and Communications is concentrated on the roads of national significance, whereas, the actual number of fatal and injury accidents and their victims in the cities and settlements is twice as much as on rural roads. The Ministry of Environment, which takes care of urban transport systems, shows no active steps to change this situation. Currently, Lithuania has no institution, which would be actively involved in the analysis of urban accidents and would submit recommendations to improve situation. The road safety improvement measures, suggested by the Ministry of Transport and Communications, are mostly oriented towards rural roads where accident causes and measures are sufficiently clear, namely: speeding, inobservance of safe distance, dangerous overtaking manoeuvres. In cities the accident causes are more complicated and subtle influenced by the environment of urban structures, transport infrastructure and road user behaviour in complicated traffic situations. It could be noticed already that the current technical urban safety measures often reduce capacity of streets and intersections, increase journey time, thus, bring back the initial causes of accidents: traffic jams, pedestrian and vehicle delays (including public transport) (Kapski, Bertuliene 2014).

The actual number of fatal and injury accidents in different months of the year in Vilnius City suggests that there is a direct relationship with traffic volume of city streets. The largest number of accidents is recorded in spring and autumn when traffic flows reach maximum values, and the lowest – in summer when traffic flows decrease to the

minimum due to schoolchildren and student holidays, and also due to the holidays of citizens spent outside the city limits.

The number of fatal and injury accidents in different hours of the day in Vilnius City correlates with the dynamics of traffic volume: the number of accidents grows in the morning and evening peak hours when the speed of traffic flows is low. This means that the main causes of accidents lie in the traffic conditions themselves with maximum number of road users. During mentioned hours the flows of public transport passengers are highest. Dynamics of fatal and injury accidents is very similar in both years 2014 and 2015. (Table 2)

The number of fatal and injury accidents in different seasons changes not much, slightly less accidents are recorded in summer when traffic flows significantly decrease. In summer the flow of pedestrians is also decreased due to the holidays of citizens, schoolchildren and students. The highest number of people are killed in winter due to prevailing darkness, reduced visibility, etc. Due to a lower traffic if vehicles and pedestrians in weekends less accidents occur. The most unsafe month was December representing more than 13 percent of the total accidents of the year.

The main type of fatal or injury accidents is collision with pedestrians. The accidents of this type make even 35.6 percent of all accidents. Other important types are collision with another vehicle (26.5 percent) and collision with cyclists (3.6 percent).

Table 2. Analysis of road accidents in Vilnius City, 2004–2015

Type of accident	2004	2005	2006	2007	2008	2011	2012	2013	2014	2015
Collision	352	404	318	293	214	158	175	222	172	184
Collision with bicycle	69	74	49	48	36	39	34	58	46	25
Collision with motorcycle						23	15	14	14	18
Collision with pedestrian	615	602	481	553	404	300	279	342	298	247
Collision with obstruction	78	69	70	48	35	15	31	24	17	19
Overturning	32	25	24	15	6	21	19	24	20	17
Collision with a standing vehicle						4	5	5	3	12
Other	53	54	54	72	29	18	58	65	67	80

A separate analysis was carried out of city locations where collisions with pedestrians occurred. The analysis showed that the accidents are more frequent in locations where there are no pedestrian crossing. In 2015, they made even 33.6 percent of the total collisions with pedestrians. On one side, these accidents could be attributed to impermissible crossing of the street, though essentially they could mean the lack of crossings in the necessary locations. Thus, it is necessary to solve an essential question of not eliminating pedestrian crossings according to the current requirements but increasing their number in the locations with pedestrian traffic.

Another cause of accidents is installation of pedestrian crossings separated from intersections, and this is very often related to improper selection of sites for public transport stops, between which pedestrian crossings are later installed. Such sites make 23.3 percent. Therefore, there are many recommendations to install new public transport stops at the main intersections and to reduce the number of potentially dangerous sites at the approaches of intersections. A larger attention must be paid when selecting sites for their safe installation according to the current requirements of Construction Technical Regulations, instead of selecting accidental sites where the stops can be installed cheaper.

In September 2014, the order No. V – 265 of the Lithuanian Road Administration under the Ministry of Transport and Communications approved *Methodology for the Identification and Elimination of Black Spots on Streets and Local Roads*. This methodology was used to identify black spots in the territory of Vilnius City 2011–2014.

Black spots are identified according to the data of fatal and injury accidents over the last 4 calendar years.

After the street (road) reconstruction or other significant improvement of traffic conditions, calculations are re-started, and the previous data of accidents having occurred before the improvements are not further used. Significant improvement means safety measures planned to be implemented to prevent accidents in black spots.

Black spots shall be identified and analysed at least every 2 years.

Algorithm for identifying black spot

1. Black spots are identified according to the data of fatal and injury accidents over the last 4 calendar years. Over this period at least 4 fatal and injury accidents shall be reported.

2. If the resources allow analysing more streets (roads) safety problems than the identified number of black spots, it is recommended to identify additional high accident concentration sections. In this case, instead of 4-year period the period of 5 or 6 years is recommended to be used.

First of all, black spots are identified at intersections. The accidents of the identified black spots are not further used in the calculations. Then, based on the data of remaining accidents, the black spots are identified on street (road) sections.

Black spots at the intersections are identified by summing up fatal and injury accidents on major and minor roads of the intersection and its approaches. Once it became clear that the accident occurred outside the limits of the analysed intersection approaches, but in its nature is attributable to the intersection, the accident shall be attributed to the intersection.

Intersection approaches in built-up area is regarded as a ±30 m distance measured from the axes of the street crossing point. Intersection approaches on the major road outside the built-up area is regarded as a ±100 m distance, on the minor road – as a ±50 m distance measured from the axes of the road crossing point (Canale *et al.* 2015).

In the period 2012–2015, the increase in the number of black spots is more of theoretical nature, related to the new recommendations and the increased number of fatal and injury accidents represented on the map according to the digital co-ordinates of 2012 and 2015. Earlier, these fatal and injury accidents without address were not included into the map. Thus, it could be stated that the total number of black spots in the territory of Vilnius City has been stabilized and remains almost unchanged. In 2012–2015, 106 black spots were identified at the intersections and other concentrated spots, and 85 linear black spots in the street sections.

In 2012–2015, the black spots were eliminated in the following locations: Šviesos No. 3, 5; Galvės–Tiškevičiaus str. intersection, Savanorių–Titnago str. intersection; Dariaus ir Girėno–Žirnių str. intersection; Naugarduko–Vytenio str. intersection; Algirdo–Šaltinių str. intersection; Goštauto–Vasario 16-os str. intersection; Lelevelio–Vilniaus str. intersection, Antakalnio Nr. 42, 44; Antakalnio–Klinikų str. intersection, Antakalnio at the Health Center; Lukšio–Žukausko str. intersection; Apkasų–Minties str. intersection; Ozo–Ralio str. intersection; Viršuliškių at the shopping center "Mada"; Ukmergės–Šeškinės str. intersection; Kalvarijų–Didlaukio str. intersection; Kalvarijų–Žvalgų str. intersection, Žirmūnų–Verkių str. intersection, Pergalės–Priekalo str. intersection, Parko–Karklėnų str. intersection.

Analysis of road accidents on streets and intersection

Comparison of 2015 accident indices in Vilnius City shows that there is no correlation between the number of fatal and injury accidents and their density. The main reason – a significantly different length of streets, which sometimes differs by ten or more times. The below table gives indicative accidents (same as accidents presented in the initial accident reports without knowing the exact place of their occurrence at the intersection) and their dynamics on the main city streets between 2005 and 2014. On the main longest Vilnius city streets dynamics of fatal and injury accidents is similar, having a tendency to grow.

Usually, the largest accident density is reported on the main short city streets. In 2014, Kareivių street can be distinguished where the density of fatal and injury accidents was 13.2 acc./1km, Pamėnkalnio str. – 8.6, Kalvarijų str. – 6.5, Šeimyniškių str. – 6.4, Gedimino av. – 5.6 acc./1km. A large accident density remains on Žirmūnų, Ozo, Kauno, Šeškinės, Žalgirio, Narbuto and other streets.

The safety situation in 2015 compared to 2014 on separate streets considerably changed. Those changes are the result of the implementation of traffic safety improvement measures. The largest decrease in accidents or no accidents at all were reported on Šeimyniškių, Kojelavičiaus, Sėlių, Pergalės, Visų Šventųjų, Jasinskio, Didžiosios, Batoro, Narbuto, Pamėnkalnio streets.

A growing tendency in the number of fatal and injury accidents at intersections is represented by Savanorių roundabout, roundabout at the Station square, Molėtų–Skersinės, Kareivių–Verkių and Kalvarijų–Konstitucijos str. intersections.

The highest number of fatal and injury accidents in 2012–2015 was recorded in Laisvės–Pilaitės, Narbuto–Geležinio Vilko, Kalvarijų–Ozo, Kareivių–Žirmūnų, Savanorių–Laisvės, Molėtų–Skersinės, Stoties–Geležinkelio, Kalvarijų–Konstitucijos str. intersections.

In the period 2012–2015, the highest number of people killed was reported in Savanorių av. (7); Eišiškių road (6); Liepkalnio (5); Ukmergės and Laisvės av. (4); Narbuto, Geležinio vilko and Dariaus ir Girėno str. (3); Žirmūnų, Žaliųjų ežerų, Galvės and Nemenčinės road (2). The highest number of deaths was reported at the following intersections: Laisvės–Rygos – 3, Savanorių–Revonių – 3, Salininkų–Avinėlių – 2, Žirmūnų–Kareivių – 2 and Kauno No. 1a – 2 people were killed.

Most of those streets are not intensively urbanized, joining with the Vilnius external road network or taking this function themselves, therefore having a higher speed limit. The mentioned streets and intersections must get additional attention, additional detailed accident analysis must be made, and conclusions on the measures to be implemented should be presented by the Road Safety Commission.

Conclusions

In conclusion, the following recommendations of general scope are given for the improvement of pedestrian traffic:

1. It is suggested to introduce a typical mandatory signing of pedestrian crossing where in recent years a collision with pedestrian occurred – a pedestrian crossing sign on a yellow background. This has been partly done, though relying on the opinion of traffic organizers. This could be validated in the Road Traffic Rules as an additional information about high accident concentration pedestrian crossing. This background at the same time improves

visibility of pedestrian crossing sign in a dark period of the day, what is especially important in single pedestrian crossings.

2. It is suggested to introduce a mandatory elimination of the warning sign about the possible children entering the street and of the green arrows for right turn within the zone of educational establishments and at intersections within this zone. The pedestrian crossing sign on a yellow background with the road sign 105 would mean that the crossing is dangerous and educational establishments are located in the nearest proximity. The additionally painted red pavement at pedestrian crossing would indicate its considerable danger.

3. The sites of high pedestrian attraction at the shopping centres, public transport stops, other are recommended to be equipped with fenced carriageways, and if this is not possible – with a barrier-type or other fencing of street carriageway. The end of fencing is at pedestrian crossing.

4. The speed limit before single uncontrolled pedestrian crossings and pedestrian crossings at uncontrolled intersections shall not exceed 50 km/h. A higher than 50 km/h speed limit behind intersections and pedestrian crossings shall be set only behind the coverage zone of public transport stop, if there is any.

5. The public transport stops at pedestrian crossings shall ensure a minimum distance to a pedestrian crossing, therefore they shall be installed at a minimum permissible distance from pedestrian crossing. In the stops of high volume traffic the distance shall be less than 55 m, of low volume traffic – 35 m. The same distances are directly applied also to the long public transport stops, situated at the pedestrian crossing, where the existing bus stop sign, obeyed by the drivers and passengers, shall be moved closer. Bringing of public transport stops closer to pedestrian crossings reduces passenger spreading zone and the number of passengers illegally crossing the street.

6. It is suggested to review all the public transport stops with pedestrian crossings which are located at a shorter distance than 100 m from the main intersections and to solve the question about the need for their relocation to the main intersection in order to eliminate another source of accidents. To seek that public transport stops are safe for passengers and are equipped with sidewalks (pedestrian track), waiting platform and illumination. The minimum street kerb height at the stops shall reach 15 cm, seeking for higher safety – 20 cm to prevent vehicles from running over the waiting passengers at the platform.

7. It is necessary to ensure a visibility triangle of uncontrolled pedestrian crossing or intersection; therefore, it is suggested to relocate public transport stops from the street turns or zones of intensive greenery. If this is not possible – to use the mandatory control measures.

8. In single local pedestrian crossings directional illumination shall be installed and safety islands. It is necessary to check how the existing directional illumination ensures the normative illumination of pedestrian crossing or intersection and what is the situation when the existing street illumination operates not in a full regime.

9. The public transport stops in historical and unsafe to passengers and pedestrians locations shall be corrected, since public transport is one of very important sources forming the concentrated passenger-pedestrian flows.

10. With the considerable increase in the number of fatal and injury accidents in parking lots and inside the city districts it is suggested to review transport and pedestrian traffic organization and parking of cars in local streets and yards and to determine their compliance with traffic safety requirements. The primary goal – elimination of possible transit traffic in residential districts.

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