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TRAFFIC REORGANISATION IN LARGE ROUNDABOUTS OF VILNIUS AND ITS INFLUENCE ON TRAFFIC SAFETY

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Abstract. Historically, there are several large roundabouts in Vilnius with traffic organisation and safety problems. Vilnius City Administration initiated changes on these large roundabouts in 2016, by introducing new traffic organisation schemes and using relatively simple measures such as the line markings, safety measures and road signs. The aim of the research is to analyse the number of traffic accidents on the roundabouts before and after such traffic reorganisation. The article is based on accident maps in roundabouts created by the authors. Based on the comparison of accident maps, the safety trends were analysed and summarised.

Keywords: comparative analysis, roundabouts, traffic accidents, traffic organisation, traffic safety, Vilnius.

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Introduction

Vilnius is the capital and the largest city of Lithuania, where the country's most important political, social, cultural and economic institutions operate. According to the data published by the Department of Statistics of Lithuania, as of 1st of July 2018, the number of permanent residents of Lithuania was 2.8 million, including 0.55 million residents of Vilnius and that was 19.6% of the total number of the inhabitants of the country (The Department of Statistics, 2018).

Vilnius City Administration initiated traffic reorganisation on large roundabouts of Vilnius in 2016. Most of the large roundabouts in Vilnius were listed as black spots in 2014 (Transport Excellence Agency, 2014). However, it should be noted that large roundabouts are problematic from the point of view of traffic safety also in other larger cities of Lithuania, i.e., Kaunas or Klaipėda (Dumbliauskas, Grigonis, & Barauskas, 2014; Sivilevičius, Paliulis, Klibavičius, & Palevičius, 2015). Black spot is a 500 m stretch of road or street with at least 4 fatalities or injuries in 4 years. Large roundabout is a roundabout with an external diameter exceeding 40 m. The further analysis concentrates on the system of such roundabouts in Vilnius (Figure 1).

Roundabout of T. Kosciuškos, Olandai and Antakalnio streets (hereafter the "Olandai Roundabout") and roundabout of Žirmūnų, Tuskulėnų and Šeimyniškių streets (hereafter the "Žirmūnai Roundabout") are the system of roundabouts connected by Žirmūnai bridge. "Olandai Roundabout" has a smaller external diameter (circa

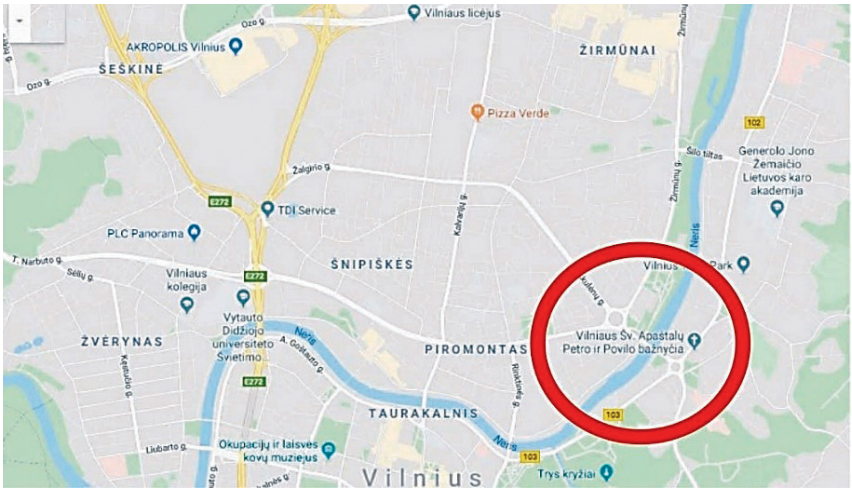

Figure 1. The geographical location of roundabouts

80 m) compared to "Žirmūnai Roundabout" (circa 120 m). This roundabout system was built in circa 1965 along with the development of Žirmūnai district. The system of roundabouts is heavily overloaded by traffic and operating in over-saturated traffic flow conditions during peak hours.

Recent theoretical and case studies (Pratelli, Sechi, & Roy Souleyrette, 2018; Wan, Chen, & Du, 2019) show that continuous and gradual improvement of a guide sign system for roundabouts improve drivers' sense of direction and it is beneficial to improve the safety and efficiency of the roundabout. Gallelli & Vaiana (2019) and Gallelli, Iuele, & Vaiana (2016) highlight that the conversion of the existing roundabout into a virtual turbo roundabout determines an increase in capacity together with a minimization of the queue lengths and potentially reduces the number of conflicts. The research by Hong Kong Transport Department (Wong et al., 2012) related to a spiral-marking system on four roundabouts indicated that there were marginal decreases in potential conflicts on medium-sized roundabouts with relatively low traffic intensity. However, performance of the spiral-marking system on roundabouts with moderate to heavy congestion is yet to be established and merits future investigation. Russo, Antonio Biancardo, & Veropalumbo (2020) pinpoint that risk assessment is one of the key elements towards proper further replication of the solutions.

The construction and operation of new roundabouts according to new standards are quite a success story in Lithuania (Žilionienė, Oginskas, & Petkevičius, 2010), but the reshaping of old type roundabouts is still a challenging issue. Therefore, the primary aim of this comparative research is to evaluate the number of traffic accidents on the roundabouts before and after traffic reorganisation (6 August 2016) on a practical level. The aim is associated with the tested hypothesis, i.e., whether better traffic organisation schemes might ensure better traffic safety in large roundabout systems. Therefore, the following objectives may be stated:

- to identify the geographical location of traffic accidents before and after the implementation of new traffic organisation scheme;
- to verify the hypothesis whether traffic organisation schemes might ensure better traffic safety in large roundabouts;
- to determine the main preconditions for more sustainable (safe) development of the large roundabouts in Vilnius.

Data source and evaluation methods:

- employment of anonymized data on traffic accidents from the Police Department Accident Register (all traffic accidents with dead or injured persons and part of the data with technical traffic accidents);

- visualization of relevant traffic accidents on the bridge and roundabouts by applying buffers in QGIS;
- preparation of the traffic accident maps with the help of QGIS and comparison of the number of traffic accidents for the selected time intervals (traffic organisation scheme was changed on 6 August 2016).

1. Major issues before the transport organisation changes in 2016

This roundabout system is a very important element for Vilnius transport system as it connects the central part of the city with Šnipiškės, Žirmūnai and Antakalnis districts, and it is essential for those arriving from Naujoji Vilnia and Markučiai districts. Traffic flows were (and still are) very high in the both roundabouts during workdays. According to the traffic counts carried out during the evening peak hour, at least 4000 vehicles were passing "Olandai Roundabout" and almost 4500 vehicles were passing "Žirmūnai Roundabout" in 2014. The capacity of "Olandai Roundabout" is exhausted and the traffic jams appear during almost all morning and evening peak hours in workdays.

Both roundabouts are quite heavily loaded by public transport (buses and trolleybuses); public transport stops are located at almost

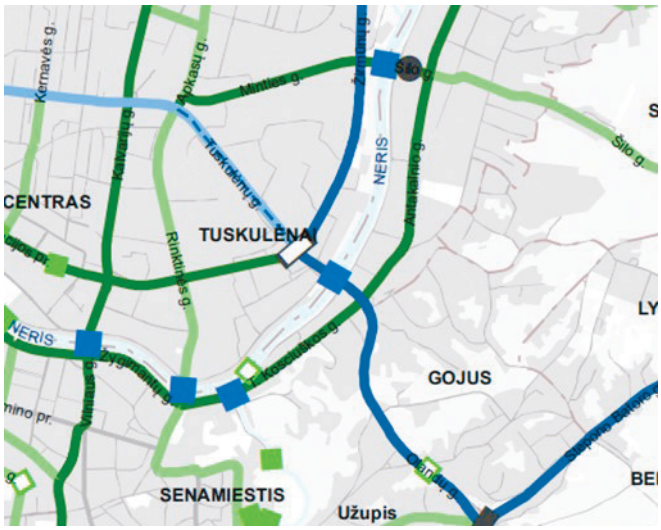

Figure 2. Street categories according to the master plan of Vilnius

every intersection leg resulting in heavy pedestrian flows. The traffic count study found that public transport accounted for 3% and lorries for 4% of the total traffic flow. The total number of pedestrians entering "Žirmūnai Roundabout" zebra crossings was 668 and accordingly in "Olandai Roundabout" – 984 pedestrians during a peak hour of non-rainy workday in 2014. These numbers provide only a general insight into traffic flows; however, further analysis concentrates on design aspects and traffic safety issues.

According to the master plan of Vilnius city municipality (2019), the street network categories are rated as follows: Olandai and Žirmūnų streets are higher B category, Tuskulėnų street are lower B category, T. Kosčiuškos, Antakalnio and Šeimyniškių streets are higher C category (Figure 2).

Street categories are the useful point of departure to foresee future design of the intersections; however, such a design usually requires a full reconstruction of the intersections with tunnels or viaducts, modern roundabouts and traffic lights. It is worth noting that German experts prepared a plan and modelled traffic lights in "Olandai Roundabout"; however, after installation and field tests the traffic lights were removed as an unsuccessful remedy in 2009. The previous (6 August 2016) traffic organisation schemes are presented in Figure 3.

Figure 3. Aerial and local view at roundabouts before traffic reorganisation (arrow in aerial view shows direction of local view, "Žirmūnai Roundabout" on the left side and "Olandai Roundabout" on the right side)

There were pedestrian crossings around both roundabouts. Pedestrian crossings were retracted by 8–4 m distance from the external boundary of the circular area and eight pedestrian crossings with islands were installed in this roundabout system.

"Olandai Roundabout" covers about 0.5 ha with an external diameter of 80 m and it had two lanes in the circulatory roadway with two approaching and exit lines. The lines in roundabout were marked with single broken and single solid lines. The road signs showed which lanes were dedicated to leave the roundabout or stay in the circulatory area. The major problem that was faced: it was possible to change lines in the circulatory area, the traffic flow was unstable and chaotic, some drivers even drove in three circulatory traffic lines (Figure 4).

"Žirmūnai Roundabout" is a larger roundabout with an external diameter reaching 120 m and it covers about 1 ha territory. It had three lanes in the circulatory roadway with two approaching and exit lines. The lines in roundabout were marked with single broken and single solid lines. The road signs showed which lanes were dedicated to leave the roundabout or stay in the circulatory area.

It should be emphasised that road markings are always done on a periodic basis, but these roundabouts were listed as black spots in 2014 (Transport Excellence Agency, 2014).

2. Transport organization changes in 2016

Vilnius City Administration and VGTU originally started from an analysis of new traffic organisation schemes with relatively simple

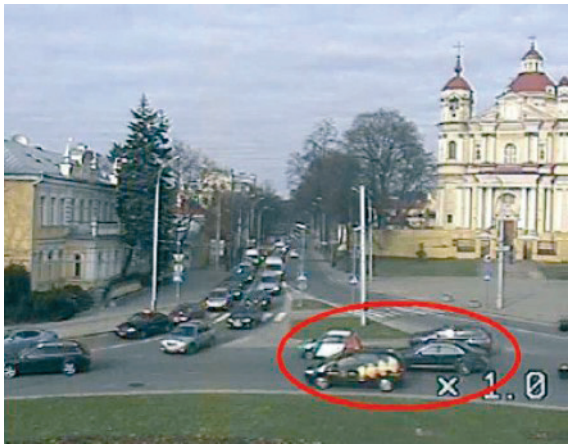

Figure 4. Car drivers do not follow traffic lanes

and low-cost measures such as the line marking, safety measures and new road signs. The new transport organisation scheme was based on the principles of spiral roundabout, which was a multilane roundabout with spiral lane markings. Concept of spiral roundabouts has originated in the United Kingdom and a robust account of design principles and their advantages is given by Tollazzi (2015). Traffic flow modelling was performed to find out better configurations of such roundabouts and the final schemes were selected as shown in Figure 5.

As drivers approach such spiral roundabouts, they have to choose the right approaching lane for their desired exit. The information concerning such a right lane is displayed in signboards (Figure 6), along with road signs and a marked driveway. All the drivers have to follow the road signs and the requirements of the Road Traffic Code.

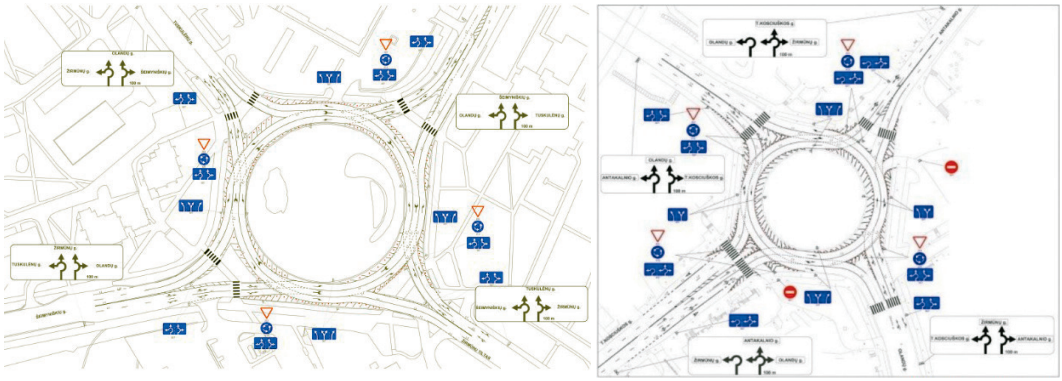

Figure 5. The implemented traffic organisation schemes in August 2016 ("Žirmūnai Roundabout" on the left side and "Olandai Roundabout" on the right side)

Figure 6. Temporary (on the left) and permanent informative road signs (on the right) informing about traffic organisation changes

After introduction of new traffic organization schemes on 6 August 2016, both roundabouts have two lanes in the circulatory roadway with two approaching and exit lines (Figure 7). The lines in the roundabouts were marked with single solid lines removing the possibility to change lanes in a circulatory roadway; clear trajectories by narrowing the carriageway were provided. One pedestrian crossing on the boundary of "Žirmūnai Roundabout" and a bridge were removed as it had the lowest pedestrian volume (88 per hour). Later on, small rubber bumps were introduced in a circulatory roadway to improve the visibility of the spiral lines. The usual blue road signs with white arrows showed which lanes were dedicated to leave the roundabout or stay in the circulatory area.

Figure 7. Aerial and local view at roundabouts after traffic reorganisation (arrow in aerial view shows the direction of local view, "Žirmūnai Roundabout" on the left side and "Olandai Roundabout" on the right side)

3. Comparison of traffic accident patterns

Lithuanian drivers are not required to call for road police, wait for the arriving crew and deal with papers for technical accidents since 2008, if there are no injuries or fatalities during the accident, two vehicles are usually involved in the accident and the drivers agree on circumstances of the accident. Since 2008, it has been possible to fill in accident declarations and deal with insurance companies. That means that only part of technical accidents is being recorded in the Police Department Accident Register since 2008. Other technical accidents are registered by private companies by completing accident declarations. However, data of private companies are not publicly available.

The extracted data from the Police Department Accident Register on traffic accidents with coordinates were uploaded to the maps using QGIS. The analysis buffer on the bridge and at roundabouts was prepared in QGIS (Figure 8). As it was mentioned, the traffic organisation scheme was introduced on 6 August 2016; therefore, evaluation was based on traffic accident data availability (948 days before changes and 948 days after changes).

More detailed breakdown by the period intervals is presented in Table 1. There were no fatal accidents during the observed period (2014–2019). In technical traffic accidents, rear-end and lateral vehicle collisions are predominant during all the periods. All in all, the number of technical lateral collisions decreased the most. In traffic accidents with injuries, a slight increase was observed. Before the changes, the injuries occurred due to running over pedestrians and lateral vehicle collisions. After the changes, the injuries occurred due to running over pedestrians and rear-end vehicle collisions.

Table 1. Comparison of traffic accidents during certain periods (based on the Police Department Accident Register)

	Previous traffic organisation (948 days)				New traffic organisation scheme (948 days)		
Year	2014	2015	2016		2017	2018	2019
Interval under consideration	01.01.–12.31.	01.01.–12.31.	01.01.–08.06.	08.06.–12.31.	01.01.–12.03.	01.01.–12.31.	01.01.–03.12.
Number of technical accidents	19	13	14	3	6	5	4
Number of accidents with injures	2	0	1	1	2	1	0
Total number of accidents	49				22		

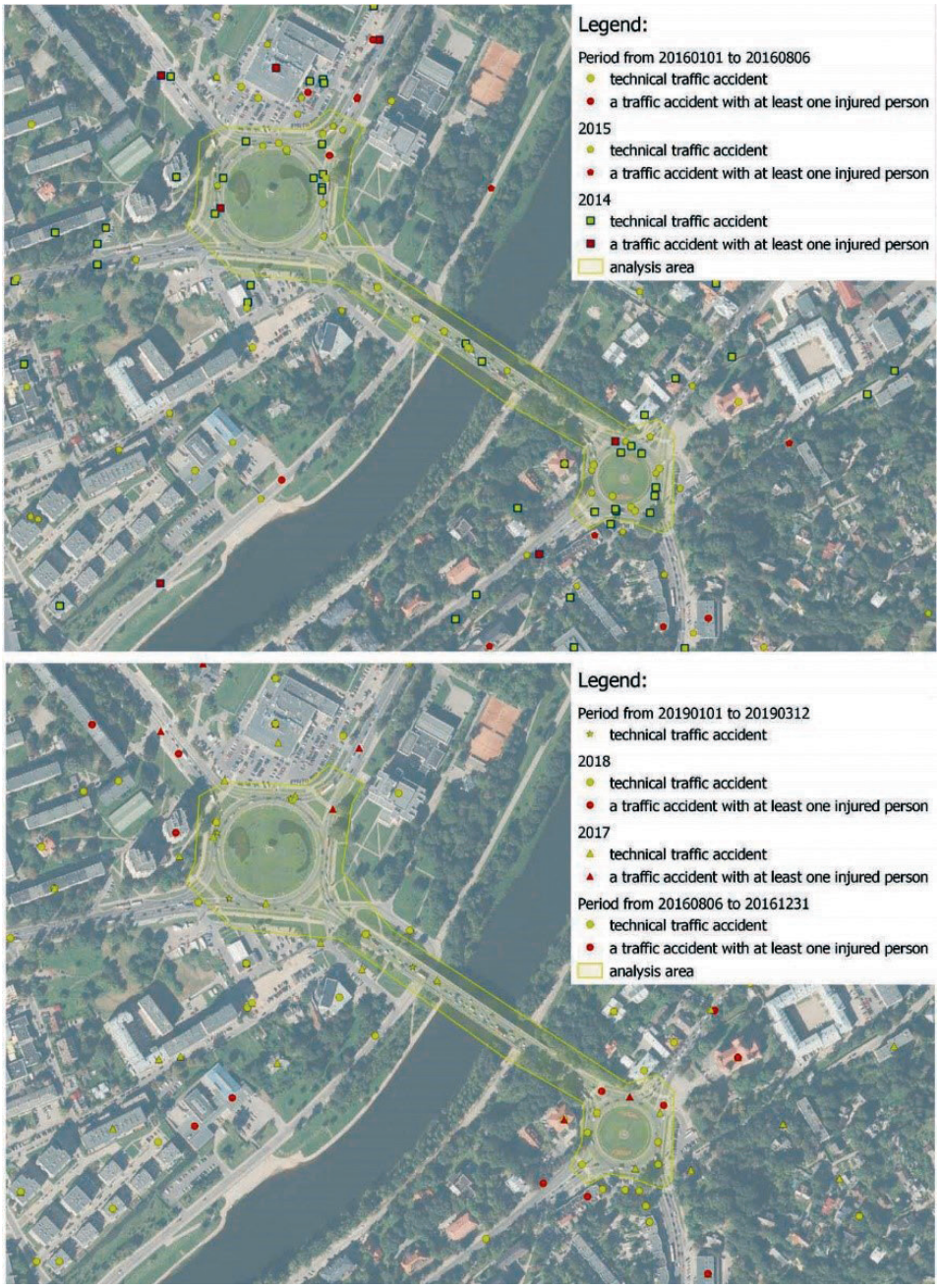

Figure 8. Location and type of traffic accidents before (top) and after (bottom) traffic reorganisation on 6 August 2016

As it has been mentioned before, part of the data about technical accidents is not available from official sources, as insurance company reports do not conduct regular analytics. However, public announcements from insurance companies show that new traffic organisation schemes lead to "simpler identification of the culprit in the traffic accidents" and "a number of traffic accidents at some roundabouts have fallen by as much as a quarter" (BTA, 2016; LD, 2018).

Conclusions

It should be emphasised that large roundabout systems were designed and built according to the Soviet normative documents in circa 1965. The current requirements for the intersection design standards are more advanced in the field of traffic safety. There are a number of opinions on the feasibility of redesigning this junction, but it is a separate topic to be analysed and developed. The paper presents a low-investment experience that was quickly implemented without huge traffic interruptions at the roundabouts.

The initial hypothesis has been confirmed at the practical level and new traffic organisation schemes ensure better traffic safety in large roundabout systems. Although other studies (Wan *et al.*, 2019; Wong *et al.*, 2012) have been more theoretical about the reduction in accidents at large spiral roundabouts, the current analysis of the changes in traffic accidents indicates that a positive trend is observed and the number of technical accidents decreased more than 2.5 times. Thus, although some accidents previously registered by the police could be expected to move to the scope of insurance companies, this was probably not the case. There is a slight increase in traffic accidents with injuries as most likely the speed in circulatory area and on exits has increased.

New traffic organisation schemes are likely to have a positive impact on road safety, but engineering measures are needed to protect pedestrians in such spiral roundabouts, i.e., to increase pedestrian visibility and possibly reduce the speed of transport at roundabout entrances and exits. An important factor of any public transport network is access to the system and particularly to public transport stops. When the commuter is walking to and from bus stops, safety on pedestrian crossings becomes very important. Therefore, regarding safety and accessibility to city stops, there is a need for overall safe street design with further attention to pedestrians.

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