Justification of the Expediency of Creating Circular Intersections in Modern Cities

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Abstract. The article resumes the principles of driving on Circular Intersections, which causes difficulties for some road users. Referring to certain foreign Traffic regulations, the author points out that such intersections are still stated imprecisely in Traffic regulations. Advantages and disadvantages of circular intersections as well as the expediency of their creation in the cities are considered in the article. The author offers to distinguish several types of circular intersections and claims that the most part of disadvantages listed in the article belong to circular intersections of the old type. On the contrary, the author presumes that creation of modern circular intersections will allow to regulate the planning of cities, make heavy traffic of transport possible while increasing the traffic safety at the same time, to improve the ecological situation of the city as well as its appearance, to carry out energy saving in the transport infrastructure of the city. All these aims could be feasible due to the creation of modern intersections of the Roundabout type.

1. Introduction
Universal circular intersections at the crossings of roads are typical for the European landscapes. Such circles (figure 1) appear even on ordinary country roads instead of traditional crossroads, typical for Russia.

![Modern Circular Intersection](image1.png)

Figure 1. Modern Circular Intersection

The popularity of circular intersections has arisen relatively recently. In the early fifties many countries replaced the circular outcomes with the traditional adjustable intersections, since the cars "in the circle" quite often rose in one continuous plug, while the traffic light regulation allowed them to move. The situation changed because of efforts of William Phelps Eno, who formulated and advanced
the main rule of ring outcomes: "During the movement the one who is in the circle, but not the one who is driving into the circle has a priority". However, it took many years to understanding that simple principle. Since the end of the 1970th almost all the countries established that "the transport on entrance is obliged to give way to the transport moving in the circle in the places of circular intersections". In the 2000th this rule began to be applied in Russia.

2. Methodology
We usual refer to the circular intersection as such a crossing of roads, where the cars, approaching it slow down speed and make the movement around the main "island". It should be noted that the carriageway in the circle is not the certain road, but only the site intended for moving out from one road to another.

The Russian Traffic regulations adjust driving on circular intersections [1]. Driving is allowed exclusively counterclockwise, and this direction is designated on the sign, put before the intersection.

Traffic regulations and the Vienna Convention on Traffic provide the necessary terminology and describe the main principles of driving on the circular intersections.

According to Traffic regulations and the Vienna Convention on Traffic, in case of turn at the entrance on the intersection, where roundabout is organized, the occupation of the extreme situation at entrance is not obligatory. The turn at the departure from such an intersection is made according the general rules.

During movement in the circle it makes sense to light on the rotary signals only at evolution from one row into another within the circle, and just before the turn at departure.

The entrance on the described road outcome is allowed from any row. It means that the driver is not obliged to nestle to the right part of the road, having seen a road sign "Roundabout" before him or her. At the same time the departure from the outcome is allowed only from the right extreme side.

Moving through the circular intersections is made in the row, chosen by the driver. If the driver decides to move closer to the central part of the intersection, he or she should light on the rotary signal of the car, according to the rules of maneuvering. It is also necessary to remember, that the traffic regulation at the circular intersection obliges the driver to be inferior a way to the vehicles, approaching on the right side (the very principle "a hindrance on the right").

In fact, there are several various types of circular intersections. The type, we got used to see in Russia is called Traffic Circle or Rotaries. A Raundebuat (or Modern Roundabout in the USA) is a bit different intersection. Roundabouts were thought up in England in the 1960th and began to be implemented gradually on the UK roads.

They showed surprising results according many parameters. The quantity of serious crashes, including accidents with deaths, was reduced by 80-90%, and the total quantity of accidents - by 40%. Capacity is 15-20% higher than at usual roundabout. The intersection perfectly manages the raised loadings, it does not demand big diameter, it is more convenient for pedestrians, it gives less harmful blowouts into the atmosphere, does not need traffic lights, helps to save energy in the municipal transport complex, etc. [2, 3].
The main difference is that, in a circle it is impossible to drive, when there is a hindrance on the left in the circle. But the cars, which are coming out from the circle to the road in other points, block driving for several seconds. This time is just enough for two or three cars to pass in their direction. That is the probability of any plug in the circle is minimum.

Another reason of the efficiency of such intersections is the absence of the crossed streams [4]. That is presented clearly in the figure 3.

Figure 3. Comparison of Rotary and Roundabout intersections from the point of view of the crossing streams

Any traditional circle, where drivers have to exchange rows, has traverses. But a roundabout does not. The entrance to a rotary functions as a freeway cloverleaf, where traffic entering the freeway from a loop ramp must weave quickly with traffic exiting the freeway at the next loop. In case of roundabout entering traffic must wait till all the lanes are clear. Such roundabouts are very popular in Great Britain, Central Europe, and they also gain popularity in North America [5].

In Holland they went further and created a so-called turbo-roundabout which is 20-30% faster and safer than an ordinary roundabout. The main difference is in the form of the central circle, which is even not a circle now, but a kind of "cutting tool". While moving in the traditional roundabout it is not sometimes clear, where the car is going to turn from the circle and thus the other drivers have to wait until it will pass before them, otherwise it is going straight and other drivers can start already. In a turbo-roundabout this defect was eliminated and moreover, they increased the safety at the entrance on the second row of the intersection for turning moving on the left and for a sharp turn at once. Now there is a physical protection there, and it is necessary to watch only one row. The result is the possibility of a faster and safer journey.

3. Results
According to the study, completed by the author, the considered intersections give the chance to unload the movement along the roads with the big stream of vehicles significantly, as they are characterized by some advantages.

1. Short waiting period. It is possible to pass a roundabout quickly enough, thanks to the absence of any traffic lights.
2. The increase in the capacity of the road section thanks to the absence of a situation "red for all the cars" which is observed at the intersections with traffic lights;
3. High level of traffic safety. Drivers dump speed before the circular intersection and that reduces the quantity of the road accidents. Even if road accidents happen, their consequences are less, than those on usual crossroads);
4. The possibility of the increase in the quantity of branches on the circular intersection without any loss of conditions for safe driving.

5. There are more opportunities for planning the city streets, which are dispersing as regular radiuses from such an intersection [6, 7, 8].

However, the analysis of the world practice (and Russian practice as well) proves, that there are some disadvantages of the considered intersections, which include the following:

1. Long time of expectation of turn for the entrance to the circle in rush hours. The matter is that drivers, who has to give way to all the drivers, who are at the intersection, sometimes expect quite long period of time. And it is not simple to come around on such an intersection in the conditions of heavy traffic even for rather skilled drivers.

2. The organization of a flow of pedestrians and cyclists becomes complicated, as usually there are no traffic lights. These groups of participants of traffic is required to pay special attention. The length of a way for pedestrians increases as a rule.

3. There is a problem with signs and illiterate drivers. The matter is that some signs at the intersection can simply be absent, and that affects the movement very negatively. Many drivers consider that their stay in the circle is already a priority. Thus there exist conflict situations among such drivers.

4. There is a danger of capsizing of cars and lorries with the raised center of gravity (if their drivers break the ordered high-speed mode).

5. The equipment of circular intersections usually requires more area, than usual. The area of the "island" in the middle of the intersection cannot be used for traffic. Landing of plants and care of them conduct to additional expenses, though the plants certainly decorate the intersection.

6. There is a probability of emergence of a conflict situation, if different road signs are put from different entrances on the intersection (for example, in case of damage of one of signs as a result of road accident). In this case, the driver who has driven on the intersection under a priority sign will consider that he has advantage before driving, and from outside, where the sign is absent, the driver will be guided by rules of moving through unregulated intersections and consider that he or she has a priority too, as he or she comes nearer on the right.

Thus, despite the fact that, some institutes, studying transport problems, strongly recommend to create such intersections, there are many responses, in which drivers and constructors sharply criticize roundabouts.

4. Discussion

Opponents name many disadvantages of circular intersections. The main reason for the criticism consists in those several seconds, for which the participant of the movement should manage to enter the circle, while there is no hindrance on the left. The second reason is the fact that evolutions are forbidden in the circle, therefore it is necessary to occupy the row in advance.

But according to the analyses of the world traffic practice, completed by the author, a modern roundabout has signs of the movement on rows. The right row is intended for the movement directly and to the right, and the left row is created for the movement directly and to the left for a turn. Thus in fact such intersection is similar to a usual departure to the road from a yard, while the observation is even more convenient. As for the movement according to rows, the usual choice of a proper row is necessary for it, just like before the intersection.

The author also considered other disadvantages of roundabout and summarized some objections.

Firstly, the modern circle intersections (MCI) are characterized by the smaller diameter of the central "island" in comparison with traditional rotaries [9]. Secondly, this "island" is actually a bed, a subject to gardening, which so are not enough in the city. Besides various installations, decorating the city space, are often put there. Meanwhile the use of this place for traffic would lead to deterioration of the urban environment. There exist numerous examples (figure 4).

The thesis, that circular intersections do complicate life for pedestrians and cyclists is also disputable. On the contrary, that is the intersections with traffic light regulation, where there appear the maximum
danger to the most unprotected participants of traffic [9, 10]. That is especially relevant for Russia, where drivers quite often pass the crossroad on red light or even take the drunk wheel.

Figure 4. Central “island” of the circular intersection with an art object (Bav Media fotobank)

At the same time pedestrians and cyclists are physically not separated from the steam of cars. The situation is quite different on the modern circular intersections, where not only "islands" of safety are equipped for pedestrians, but also the special landscape protections, separating them from the moving transport are created (figure 5) [5].

Figure 5. Modern one-row circular intersection

Perhaps, the general pedestrian way "within the circle" increases, but people can safely stay on a safety "island". The speed of cars on the modern circular intersection cannot be too high because of some objective reasons, and that also simplifies the way for pedestrians [5].

As for some other disadvantages, they do not maintain any criticism. In case of a dense steam of cars the traffic blocks will be on any intersection, but the modern circular intersection will help to manage this trouble quicker. As for the excess of the high-speed mode, it is the traffic offense that in general is inadmissible on any roads. The probability of a conflict situation arises only in those countries where the "golden rule" by Phelps Eno is broken [11, 12].

But what about the advantages of circular intersections? There are many more of them. We can address statistics (the data of the American Institute of road safety obtained the results of the analysis of 24 road traverses in the USA [13, 14]).

Total number of road accidents on the modern circular intersections, compared with the intersections with traffic light regulation is 39% less.

The quantity of the road accidents, which led to injuries of their participants is 76% less.

The quantity of road accidents with deaths is 90% less.
Similar data from other information sources do not strongly differ from the aforesaid. The matter is that the design features of roundabouts compel the drivers (without exception) to reduce speed, undergoing the crossing of roads, and thus them reduce the probability of loss of control by the driver during the movement (figure 6). In the figure 6 red shooters demonstrate the direction of the movement on the intersection.

![Figure 6. Measures for reduction of the speed of the car at entrance on the modern circular intersection](image)

At the same time, the traffic light physically does not limit the speed anyhow. On the contrary, some situations when drivers, hurrying to be in time on green light, even increase their speed on the intersection with traffic light regulation are known.

But the increase in safety for all the participants of the movement (without exception) does not exhaust the advantages of modern circular intersection.

Besides roundabouts absolutely eliminate the situation of the "left turn" (for right-hand traffic), which is one of the most difficult and potentially dangerous maneuvers on the road. And in general, the quantity of conflict points (places where ways of transport are crossed and, therefore, dangerous situations are possible) at modern circular intersections much less (figure 7).

![Figure 7. Conflict points: the comparative analysis of usual crossroad and MCI [12]](image)

It should be also mentioned, that on the roundabouts even in the conflict points cars can collide, as a rule, at an acute angle, i.e. that would be the sliding movement, but not "a forehead sideways" collision or "a forehead in a forehead" collision, as it quite often happens on usual crossroads, which is certainly potentially more dangerous. We should not also forget about the high-speed mode which, when moving
on a curve (on modern circular intersection) is obviously lower, than during the direct movement, which is characteristic of right-angle crossroads.

The opponents of roundabout can object, that the safety requires to endow the capacity reduction of the MCI and that, as we know, the circular outcomes sometimes fell in strong jams. But, as practice proves, such consideration is wrong and characteristic only of those countries, where Phelps Eno's rule for circular outcomes is broken. But if there exist the priority of the drivers who are in the circle, but not on the entrance, the capacity of such outcomes increases, being compared with any traditional crossroad. It occurs because, having driven into the circle, the driver moves unceasing and leaves the circle quickly enough, thereby making space for other participants. But any traffic light regulation stops the stream for the period of action of red signal.

According to some research, the capacity of MCI is on average is 30-50% higher. But the same research emphasize, that the capacity of MCI even of the same type differs in different countries and cities. A lot of things depend on the mentality of inhabitants [10, 14-16] and total of the vehicles, which are carrying out the movement. Nevertheless, researchers are unanimous: in general, passing of a circular outcome takes less time and less delays than traditional adjustable or unregulated intersections.

The last from the aforesaid factors directly influences an ecological situation in the location of roads crossing [15, 19, 20]. Due to the decrease of total delays and total time spent by cars with the switched-on engines, the amount of harmful blowouts of exhaust gases into the atmosphere decreases too. It is promoted also by big smoothness of the movement in the "circle", when the driver almost should not carry out speed-ups and braking as at the traditional intersection. In addition, it also promotes the general drop of noise level from the moving transport while it is known that starting or slow-downing cars rustle most of all.

5. Conclusions

Thus, the analysis of Traffic regulations as well as the analysis of the world practice proves that modern circular intersections have more advantages, than disadvantages.

Surely, there are cases, when the creation of a circular intersection is inexpedient and it is better to make the traditional crossroad. But nevertheless, taking account the Russian conditions, when Traffic regulations are applied selectively and often treated "according to a situation", while the restrictive measures are not always effective, the circular intersection, on which drivers are physically deprived of any opportunity to create dangers to themselves and others, are almost the only real possibility of the organization of safe traffic. The Russian cities will gain much, if such intersections appear in our country soon.

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