# SLOVENIAN EXPERIENCES WITH “TURBO – ROUNDABOUTS”

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**Sažetak:** Ideja kružnih raskrižja sa spiralnim tokom cirkulacijskog kolnika ("turbo-kružna raskrižja") je vrlo brzo prenesena i u slovenski okoliš. Za to postoji više razloga. Jedan od najvažnijih razloga je sigurno činjenica da su u prošlosti u Sloveniji građena premala dvotračna kružna raskrižja, što se protivilo zakonskom pravilu o obveznom korištenju unutarnje cirkulacijske prometne trake u slučajevima kada vozač ne napušta kružno raskrižje na prvom sljedećem izlazu (prosječni vozač nema dovoljnu duljinu za promjenu vozne trake na cirkulacijskom kolniku). Drugi razlog je da unutarnja cirkulacijska prometna traka na kružnom kolniku nije "zanimljiva" mladim i starim vozačima, zato što se osjećaju nesigurnima pri promjeni trake. Trenutno su u Sloveniji uvjeti sljedeći: postoji sedam realiziranih turbo kružnih raskrižja, jedno turbo kružno raskrižje u izgradnji, za pet turbo kružnih raskrižja projektna dokumentacija je u fazi odobravanja. Također smo usvojili i naše smjernice za planiranje i projektiranje kružnih raskrižja sa spiralnim tokom cirkulacijskog kolnika (turbo kružna raskrižja). Mada je prvo turbo kružno raskrižje u Sloveniji izgrađeno tek 2008. godine (ostala su izgrađena 2009. i 2010. godine), u članku su prikazana neka trenutna iskustva s turbo kružnim raskrižjima u Sloveniji.

**Ključne riječi:** prometna sigurnost, kružno raskrižje, turbo kružno raskrižje, Slovenija

**Abstract:** The idea of roundabouts with the spiral course of the circulatory carriageway (“turbo-roundabouts”) was very rapidly transposed into the Slovenian environment as well. There are more reasons for that. One of the most important reasons is surely the fact that in the past, too small two-lane roundabouts were being constructed in Slovenia, which contradicted the statutory rule of the mandatory use of the inner circulatory traffic lane in cases, when the driver does not leave the roundabout at the first next exit (an average driver does not have the sufficient length to change the driving lane in the circulatory carriageway). The second reason is that the inner circulatory traffic lane in the circulatory carriageway is not “interesting” for the young and the senior drivers, because they feel insecure, when they change lanes. Currently, the conditions in Slovenia are the following: there are seven implemented turbo roundabouts, one turbo roundabout under construction, for five turbo roundabouts the project documentation is in the stage of confirmation. Also, we adopted our guidelines for the planning and designing of roundabouts with the spiral course of the circulatory carriageway (turbo roundabouts). Although first turbo roundabout in Slovenia was build up not earlier than in 2008 (the others in 2009 and 2010) in the article some momentary experiences with turbo roundabouts in Slovenia are shown.

**Key words:** traffic safety, roundabout, turbo roundabout, Slovenia

## 1. SLOVENIAN STATE-OF-THE-ART IN THE FIELD OF ROUNDABOUTS

During past almost twenty years in the Republic of Slovenia the roundabouts have become more and more interesting for both designers and investors. Until that time, in Slovenia we practically had no significant experiences with roundabouts and their advantages in road traffic.

At the moment, in Slovenia we have 256 (ordinary) roundabouts, 72 % on state roads, 28% on municipality and private roads. We have approximate one hundred fifty one-lane roundabouts (Figure 1), approximately forty two and three lanes roundabouts, about twenty mini roundabouts, some large roundabouts (above or under the highways), and some examples of double roundabouts from both sides of highways (“dumb – bell” roundabouts) – instead of “diamond junction” (Figure 2) and also seven turbo roundabouts.

Figure 1. Typical Slovenian one-lane roundabout

Figure 2. Slovenian “dumb – bell” roundabout in Maribor

In the future, it is not expect, that we will build any square roundabouts with square center island in Slovenia (as it is known from Great Britain), neither square roundabouts with circle center island - although their capacity is large (two vehicles on roundabout’s entrance at the same time). It is also not expected, that double mini roundabouts will be build in Slovenia - or maybe just some lonely cases of them. Maybe there will be some examples of double roundabouts with joint splitter island (“dog-bone”) - they are also very popular in UK and in The Netherlands now. Probably we will not implement roundabouts with transition central island (“hamburger”), neither up-grade (two-level) roundabouts. But in short we could expect more turbo roundabouts and traffic-lighted turbo roundabouts (Figure 3).

Figure 3. The first Slovenian traffic-lighted turbo roundabout in Ljubljana: equipped with traffic lights on each entry and on inner lanes (dynamic controlled, with in-pavement detectors)

## 2. THE HISTORY OF SLOVENIAN TURBO ROUNDABOUTS

### 2.1. Basic facts about turbo roundabout

In turbo roundabout traffic flows run separately before the entry into the roundabout and they occupy separate lanes all the way throughout the roundabout.

Physical separation of traffic lanes is interrupted only in places of entry into the inner roundabout traffic lane – this physical separation is achieved by specially shaped elements, which divert drivers to change traffic lanes in the roundabout (Figure 4).

Figure 4. Physical separation between driving lanes in turbo roundabout

According the physical separation of traffic lanes in turbo roundabouts we must addressed basic distinction between two lanes roundabout and turbo roundabout. Two lanes roundabout has more conflict points – and many of those conflict points are not in “exact position” (for example conflict points of weaving). With turbo roundabout we eliminate those weaving conflict points – and for the remaining conflict points we know the exact position, which is also very important (see Figure 5).

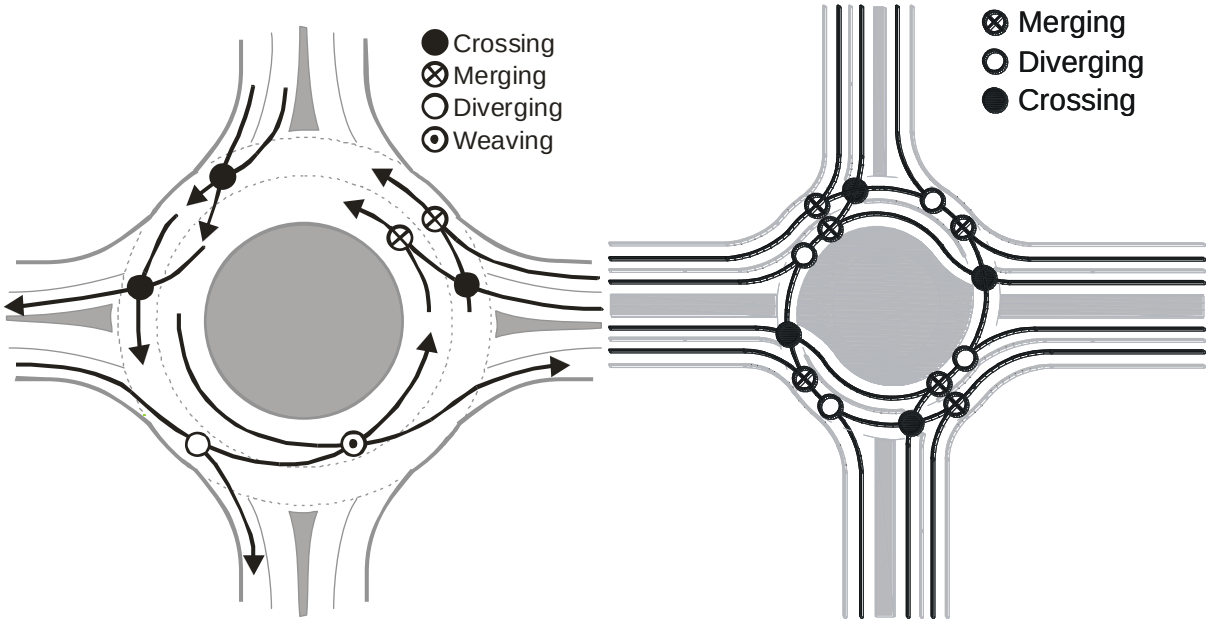


Figure 5. Conflict points in two lanes roundabout (left) and in turbo roundabout (right)

But – like in other types of multilane roundabouts – also in turbo roundabouts we must devote a lot of attention to the traffic safety of non-motorized traffic participants. Main problem is crossing of pedestrians and / or cyclists over 4 (or in some cases even more) driving lanes. The problem could be solved by:

- speed control at the entries and exits;
- separation of entry traffic lanes with intermediate splitter island (see Figure 8 and 22);
- deviated position of the pedestrian and cycle crossing at the entry and exit (see Figure 6);
- leading non-motorized traffic participants in different level (see Figure 6 and 20).

Figure 6. Deviated position of the pedestrian and cycle crossing (left) and leading non-motorized traffic participants in different level (right)

According to Slovenian experiences we could conclude, that turbo roundabout is appropriate solution on locations outside urban areas and when we have insignificant / small portion of non-motorized participants (pedestrians, cyclists). The selection of the type of the turbo roundabout depends on the predominant direction of the main traffic flow.
Turbo roundabout could be conditionally appropriate solution instead of existing traffic-overloaded one-lane or two-lanes roundabouts, instead of existing less safe two-lane roundabouts (e.g. too small two-lanes roundabouts) or in cases of reconstruction of the classic intersection with a predominant main traffic direction (with a very strong traffic flow).

### 2.2. Process of introduction of turbo roundabouts in Slovenia

The idea of roundabouts with the spiral course of the circulatory carriageway was very rapidly (in a few years) transposed into the Slovenia as well. There are more reasons for that. One of the most important reasons is surely the fact that in the past, too small two-lane roundabouts were being constructed in Slovenia, which contradicted the statutory rule of the mandatory use of the inner circulatory traffic lane in cases, when the driver does not leave the roundabout at the first next exit (an average driver does not have the sufficient length to change the driving lane in the circulatory carriageway). The second reason is that the inner circulatory traffic lane in the circulatory carriageway is not interesting for the young and the senior drivers, because they feel insecure, when they change lanes.

### *Year 2002: The first Slovenian ideas*

Accordingly, the first ideas on the implementation of turbo roundabouts began to appear also in Slovenia, already in 2002. The ideas were created in the cooperation between the “University” and the “project-planning firms”. The first concept of solution that included the turbo roundabout appeared in Maribor (Figure 7).

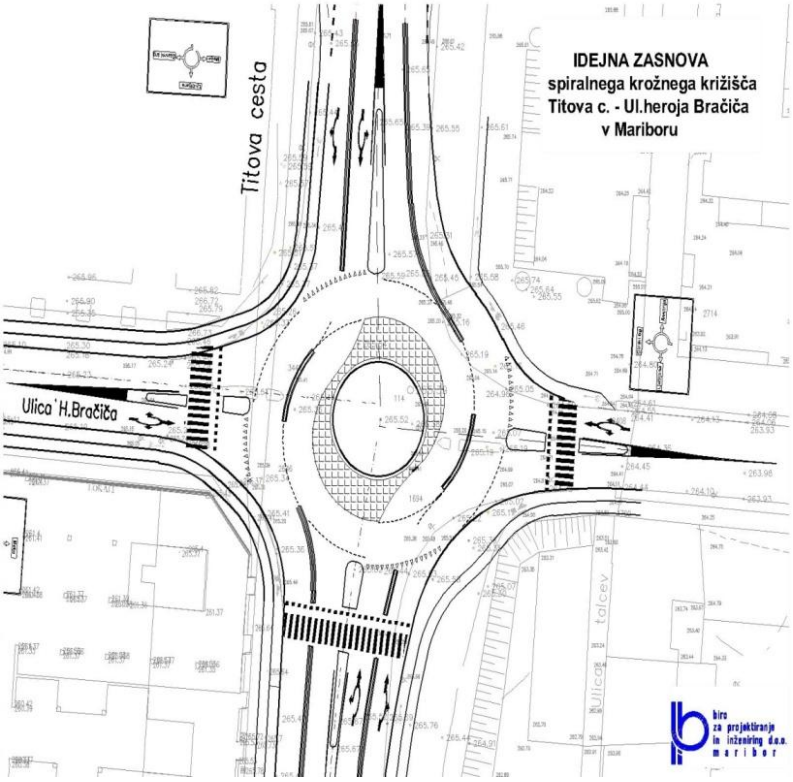


Figure 7. The first Slovenian idea for solution that included the turbo roundabout

### *Year 2004: Serious contemplations on the implementation of the first turbo roundabouts*

In 2004, we were in the same position as we were about 20 years ago, when we began with the implementation of the “normal” roundabouts. At that time, we had no guidelines nor did we have the institution, which would be able to determine with certainty, which of the foreign guidelines were the most appropriate for Slovenia. We had no experiences in planning and designing, no support of the media, no cooperation of the traffic police, no support of driving schools and no written rules on how to drive in a roundabout.

Considering the condition at the introduction of “normal” roundabouts, the situation was a bit more serious. Until then, the roundabouts with the spiral course of the circulatory carriageway were implemented only in The Netherlands, we had no knowledge of what would happen with the capacity of these types of roundabouts in Slovenian conditions and we were not familiar with any results of the traffic safety analyses in these roundabouts.

Because of all of the above, it was more than obvious that we must “travel the same road” again. This means that we had to create basic guidelines for planning this type of roundabouts in Slovenia, implement a few examples of such roundabouts in a real environment, monitor and determine potential problems and uncertainties during the construction, seriously establish monitoring of their operation after the implementation, while supplementing guidelines for their planning with new findings throughout the whole process.

Before that, we visited the Netherlands on two occasions. We inspected several roundabouts of this type, acquired the project documentation from their Ministry of Transport and had a meeting with Mr. Fortuijn, “the father” of roundabouts with the spiral course of the circulatory carriageway.

### *Year 2006: Intensive preparations for the beginning*

This year, the project documentation for the first two Slovenian cases was created. The process of revising and confirming the project documentation was quite long, considering the fact, that we were dealing with a novelty in the Slovenian environment and that we had to verify whether any of the elements of the roundabout of this type contradicts the applicable legislation from the field of the road planning. In two parts of Slovenia, two roundabouts of this type began to be implemented simultaneously. In the north-east part of Slovenia (city Maribor) and in the south-west part of Slovenia (city Koper).

### *Year 2008: The first implemented cases*

The whole time, the construction sites were under control of the competent institutions and persons, who assumed the responsibility for their implementation. The Slovenian guidelines for the planning and designing of roundabouts with the spiral course of the circulatory carriageway (turbo roundabouts) were being supplemented throughout the whole process. In July 2008, the first Slovenian turbo roundabout (Figure 8) was concluded, the second one (Figure 9) was finished in 2009. Three more proposals were in the revision process that year.

### *Year 2011: The condition today*

Currently (May 2011), the situation in Slovenia is the following:

- there are seven implemented turbo roundabouts,
- one turbo roundabout is currently under construction,
- for five turbo roundabouts, the project documentation is in the stage of confirmation,
- Slovenian guidelines for the planning of roundabouts with the spiral course of the circulatory carriageway (turbo roundabouts) were adopted.

Figure 8. The first Slovenian turbo roundabout – under construction; city Koper, 2008

Figure 9. The second Slovenian Turbo Roundabout – under construction; city Maribor, 2009

### *2.3. Turbo roundabouts in Koper*

Koper is the 5-th largest Slovenian city (population: 47.539, area: 311,2 km$^2$). It is the Mediterian city and present commercial and tourist center on Slovenian coast. In Koper there is important port "Luka Koper", which generates quite amount of commercial traffic. Koper is also known as “city of roundabouts”. Currently they have four turbo roundabouts, one is under construction (Figure 10). Due to limited space we will detail present just two of those four turbo roundabouts.

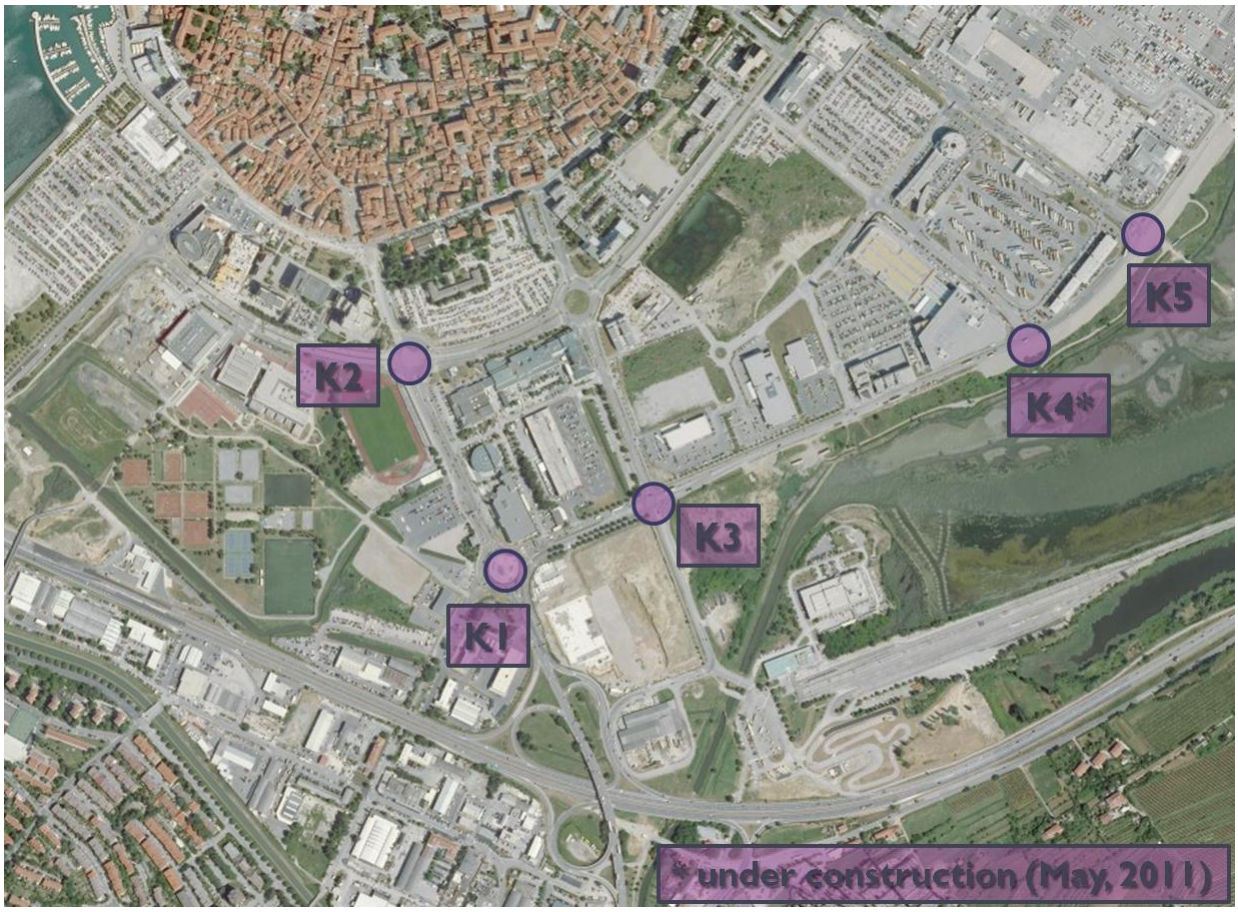


Figure 10. Turbo Roundabouts in Koper

### *2.3.1. K1: “Lesnina”*

This was the 1-st Slovenian turbo roundabout (see Figure 11 and 12). It was opened in 2008, it has 4-arms and main radius R1 = 19 m. Pedestrian and cyclists crossings are arrange just over 2 arms. It has AADT with apr. 30.000 vpd.

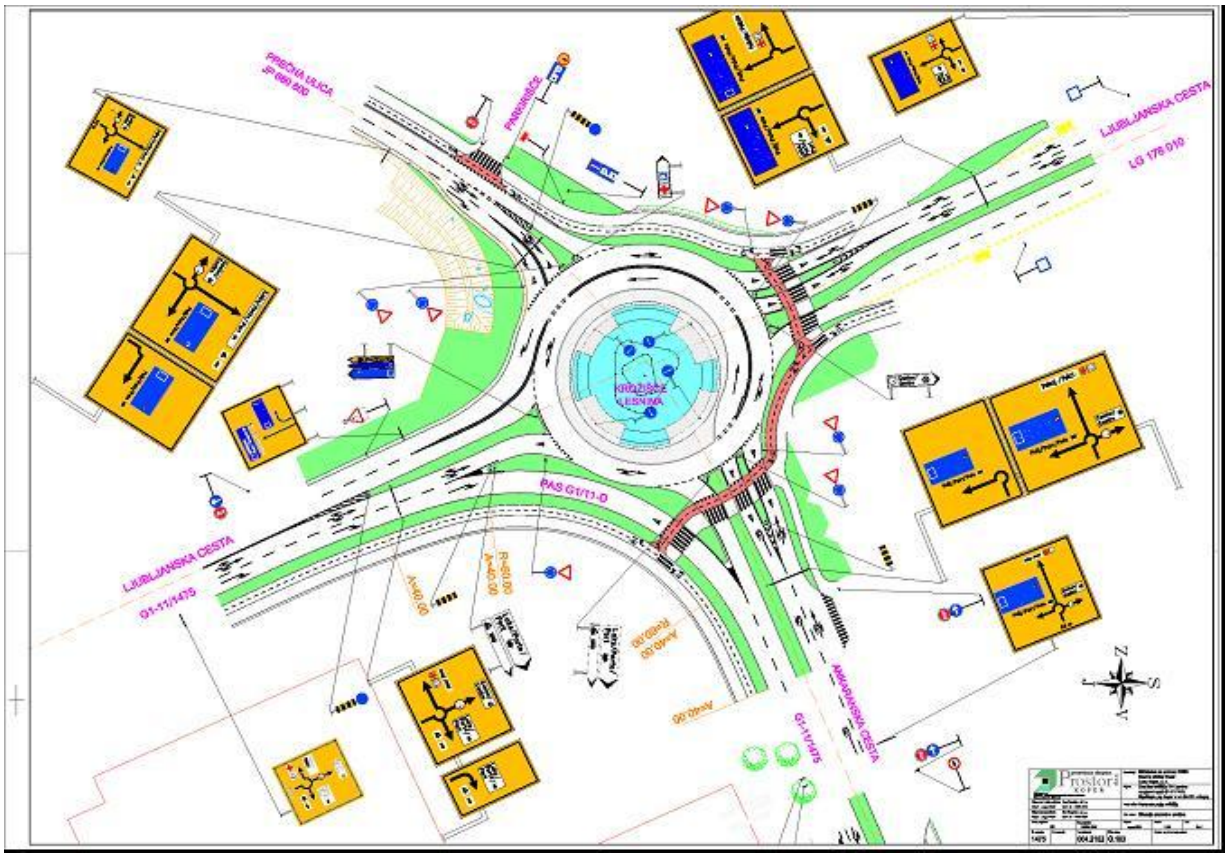


Figure 11. Turbo Roundabout K1 “Lesnina” in Koper: design plan

Figure 12. Turbo Roundabout K1 “Lesnina” in Koper

### *2.3.2. K5*

This is the last turbo roundabout in Koper – opened in 2011 (see Figure 13 and 14). It has 3-arms and with main radius R1 = 15,75 m present “standard turbo roundabout”. Pedestrian crossings are arranged over 2 legs, cyclist’s crossings over 1 leg. It has AADT with apr. 21.000 vpd.

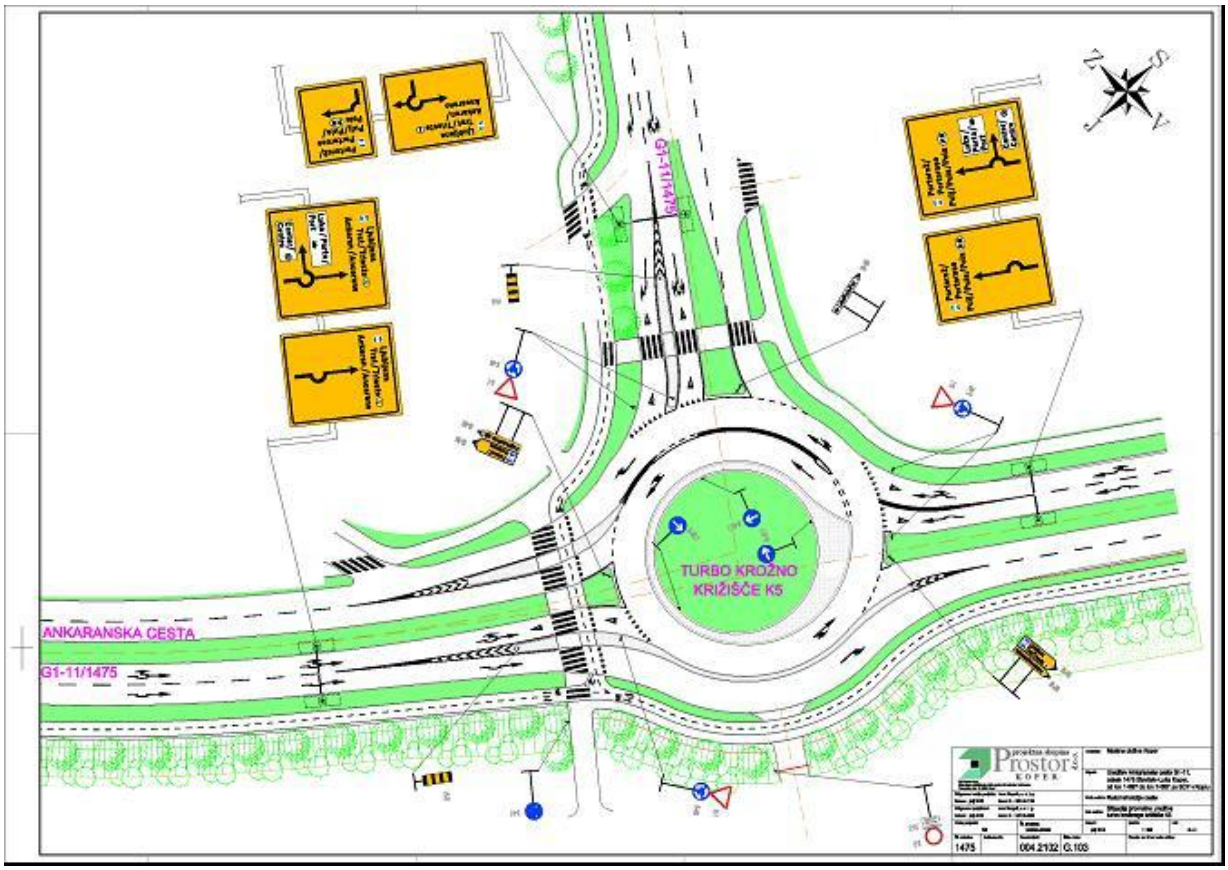


Figure 13. Turbo Roundabout K5 in Koper: design plan

Figure 14. Turbo Roundabout K5 in Koper

### *2.4. Turbo roundabouts in Maribor*

Maribor is the 2-nd largest Slovenian city (population: 129.071, area: 147,5 km$^2$). It is the University, economic, cultural, traffic and tourist centre of northeast Slovenia. Maribor is also known as “pioneer city of roundabouts”. In Maribor we get first temporary / assembled roundabout, one of the first mini roundabout, second turbo roundabout etc. Currently we have three turbo roundabouts (Figure 15). Due to limited space we will again detail present just two of those three turbo roundabouts.

Figure 15. Turbo Roundabouts in Maribor

### *2.4.1. M1: “Titova”*

This was the second Slovenian roundabout (see Figure 16 and 17). It is special because of its oval / elliptical shape (due to space limitation). It has 4-arms with pedestrian and cyclists crossings over 2 (minor) legs. It has AADT with apr. 35.000 vpd.

### *2.4.2. M3: “Lackova”*

This was the 5-th Slovenian roundabout, open in 2009 (see Figure 18, 19 and 20). It has 4-legs (currently 3 – one leg will be continuation of west / south Maribor by-pass). It is special because it is the first Slovenian turbo roundabout with underpass for pedestrians and cyclists.

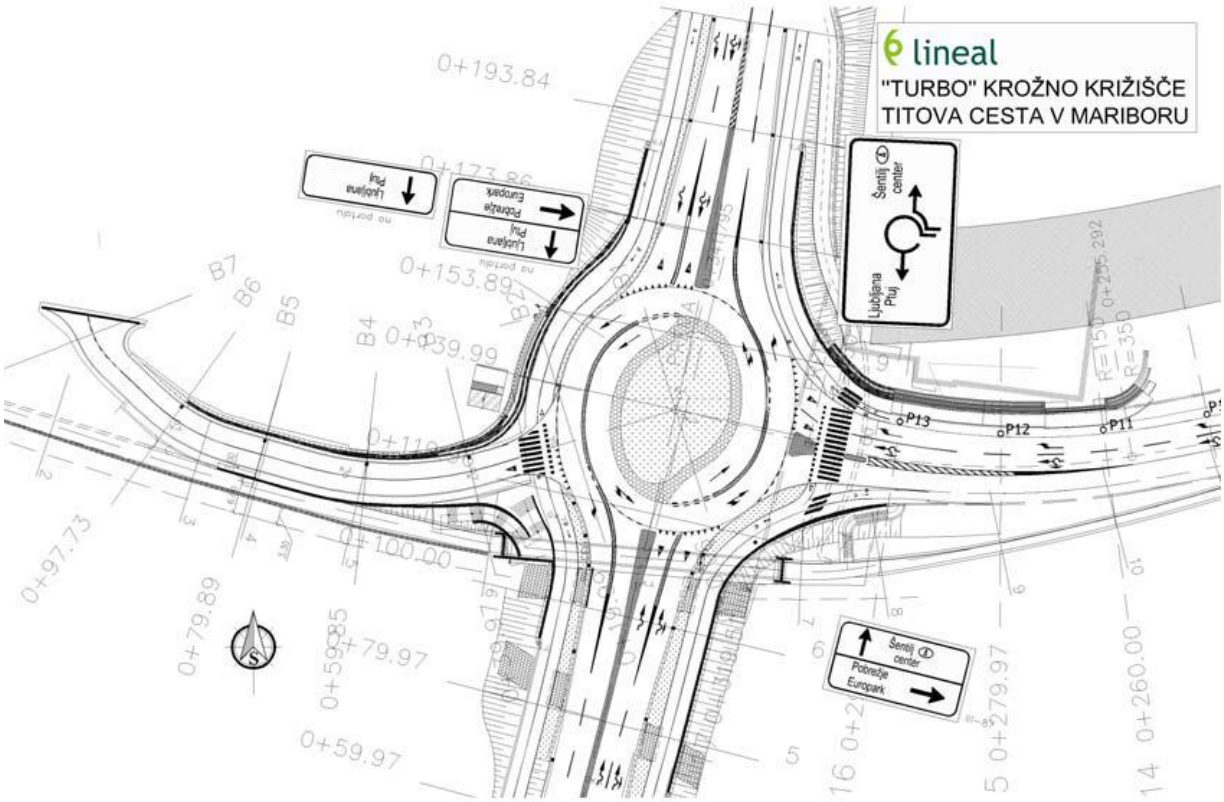


Figure 16. Turbo Roundabout M1 “Titova” in Maribor: design plan

Figure 17. Turbo Roundabout M1 “Titova” in Maribor

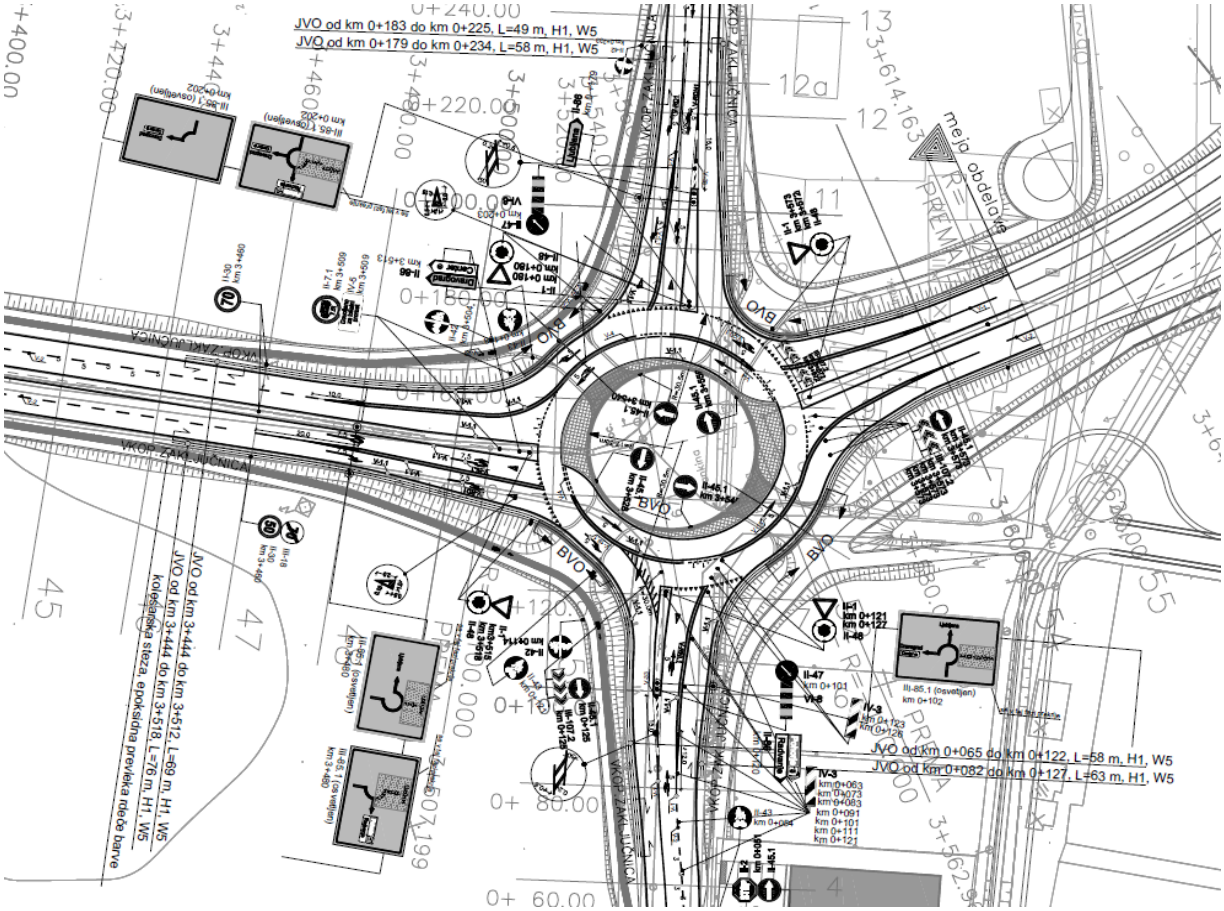


Figure 18. Turbo Roundabout M3 “Lackova” in Maribor: design plan (BPI Ltd)

Figure 19. Turbo Roundabout M3 “Lackova” in Maribor

Figure 20. Turbo Roundabout M3 “Lackova” in Maribor: underpass for pedestrians and cyclists

## 3. SLOVENIAN EXPERIENCES WITH TURBO ROUNDABOUTS

All seven of the Slovenian turbo roundabouts are still under monitoring and analyses of their operation, since they are still ”fresh” and we cannot yet guarantee that they shall be as successful as in the Netherlands.

Since first turbo roundabout in Slovenia was build up in summer 2008, next four turbo roundabouts in 2009, one turbo roundabout in 2010 and one in 2011, we could not yet perform detailed “before – after” study of existing turbo roundabouts in Slovenia. However, in continuation of this paper we present our experiences with turbo roundabouts, which we collect since their opening.

### 3.1. Design of turbo roundabouts

According to our guidelines for turbo roundabouts design we established some changes regarding the Netherlands typical turbo roundabouts. Basic differences are:

- we apply little larger dimension for radius;
- we establish different construction (detail) of the starting area of the element for preventing weaving – “peak” of dividing element (Figure 21), This change was made to assure easiest winter maintenance (snow plowing);
- for pedestrians and / or cyclists crossing we adopt solution, where pedestrians and / or cyclists cross just one by one driving lane separately – with intermediate splitter lane (“waiting area”) between two driving lanes (Figure 22).

### 3.2. Driver opinion

According to drivers opinion turbo roundabout is very safety due to following reasons:

- driver is all the time in his “own” line;
- there is no weaving in circulatory carriageway;
- it is always clear who have the priority;
- no fears and doubt when driving in inner circulatory carriageway;
- lower speed compare to “common” multi-line roundabouts;
- traffic signalization is easily understood and unmistakable.

Figure 21. Different construction of starting area of the dividing element: in the Netherland (left) and in Slovenia (right)

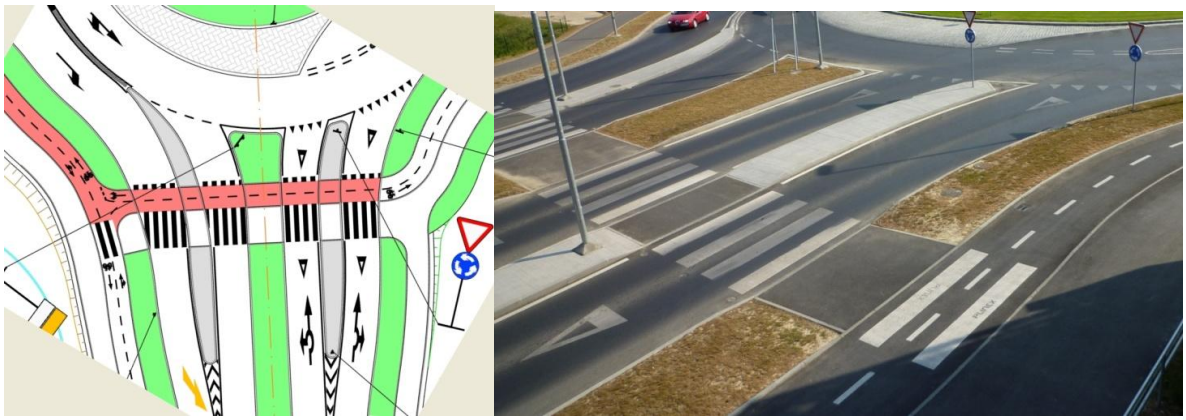

Figure 22. Arrangement of pedestrians and cyclists crossing in turbo roundabout in city Koper

### 3.3. Capacity

The same good experiences with turbo roundabouts we also have according to capacity. No bottlenecks are establish, daily traffic in that turbo roundabouts is between 38.000 to 42.000 vehicles per day.

### 3.4. Traffic safety

In general, we can establish that turbo roundabouts in Slovenia have met the expectations – as concerns the large capacity and particularly the high level of traffic safety. We must stress at this point that traffic accidents in Slovenian turbo roundabouts are an exception and not a rule. These accidents normally result only in material damages.

According to statistical data about traffic accidents in Slovenia we found out that just few traffic accidents in turbo roundabouts – till now – occurred. Those recorded traffic accidents resulted just with material damage.

If we compare turbo roundabout with “classic” two lanes roundabout we could conclude, that turbo roundabout is better solution – from traffic safety point of view. In turbo roundabouts namely could not appear conflicts / traffic accidents, which are result of weaving between vehicles in roundabout.

## 4. CONCLUSION

Process of introducing turbo roundabouts and good experiences with that type of roundabouts in Slovenia is presented.

The idea of roundabouts with the spiral course of the circulatory carriageway (“turbo-roundabouts”) was very rapidly transposed into the Slovenian environment as well, and there are more reasons for that.

The first ideas on the implementation of roundabouts with the spiral course of the circulatory carriageway began to appear in Slovenia in 2002. Today there are seven implemented turbo roundabouts; one roundabouts of this type are under construction, for five roundabouts of this type, the project documentation is in the stage of confirmation.

That type of roundabouts in Slovenia comes into effect very quick. Mostly because of positive driver’s opinion and high traffic safety level, which that type of roundabout offers. It is expected that in the future the number of turbo roundabouts in Slovenia will increase.

In general we can establish that turbo roundabouts in Slovenia have met the expectations as concerns the large capacity and particularly the high level of traffic safety. At this point we must say that traffic accidents in Slovenian turbo roundabouts are an exception (and not a rule) and that these accidents normally result only in material damages.

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