



Faculty of Civil Engineering, Transportation Engineering and
Architecture

Dr. Tomaž TOLLAZZI
Full Professor of Civil and Traffic Engineering

Slovenian Experience with Roundabouts and Alternative types of Roundabouts

SLOVENIA: STATE-OF-THE-ART

In 1992 process of introducing roundabouts in Slovenia started, although we had some lonely examples before.

At the moment, in Slovenia we have apr. 700 roundabouts, apr. 42 % on state roads and apr. 58% on municipality and private roads.

We have approximate 480 one-lane roundabouts.



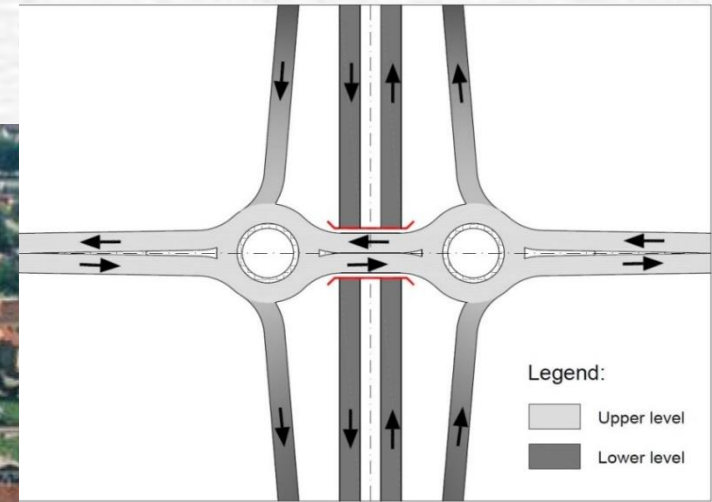
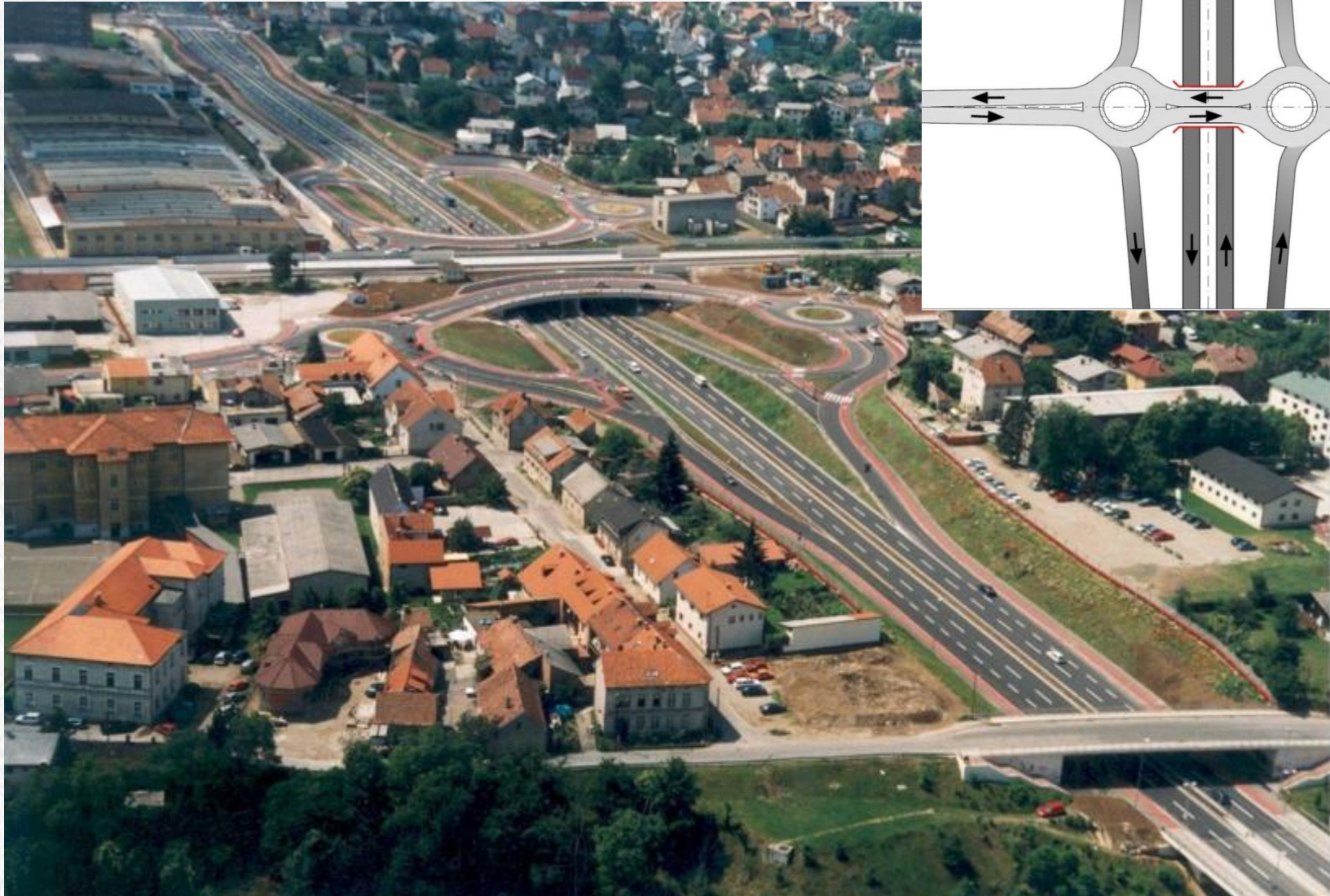
... approximately sixty multi-lane roundabouts are implemented...



... also some giant roundabouts (above or under highways and motorways) ...



... we have a lot of dumb-bell roundabouts (double roundabouts from both sides of highways and motorways) – instead of “diamond junction”, because of three reasons



... in future it is expected that more mini-roundabouts will be implemented in Slovenia ...



... with implementation of first assembly-roundabouts our ripeness on this field was prove, that we absorbed initial steps and experiences ...



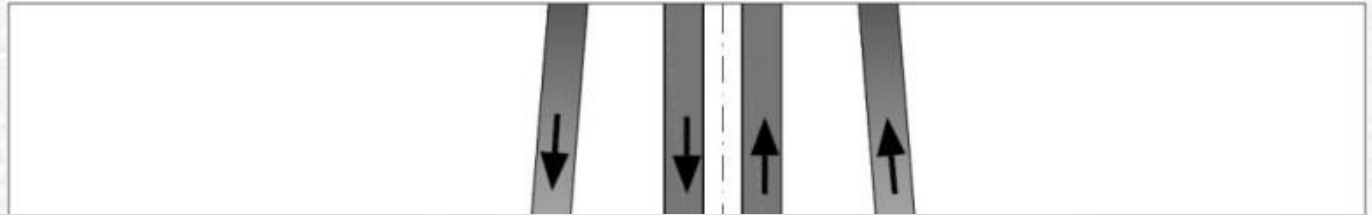
In the future in Slovenia, it is not expected to build any hamburger roundabout (roundabout with a transitional central island) ...



... but we could expect more traffic-signal controlled roundabouts ...



... and also more **dog-bone roundabouts.**



... and we already have one cyclist's roundabout.

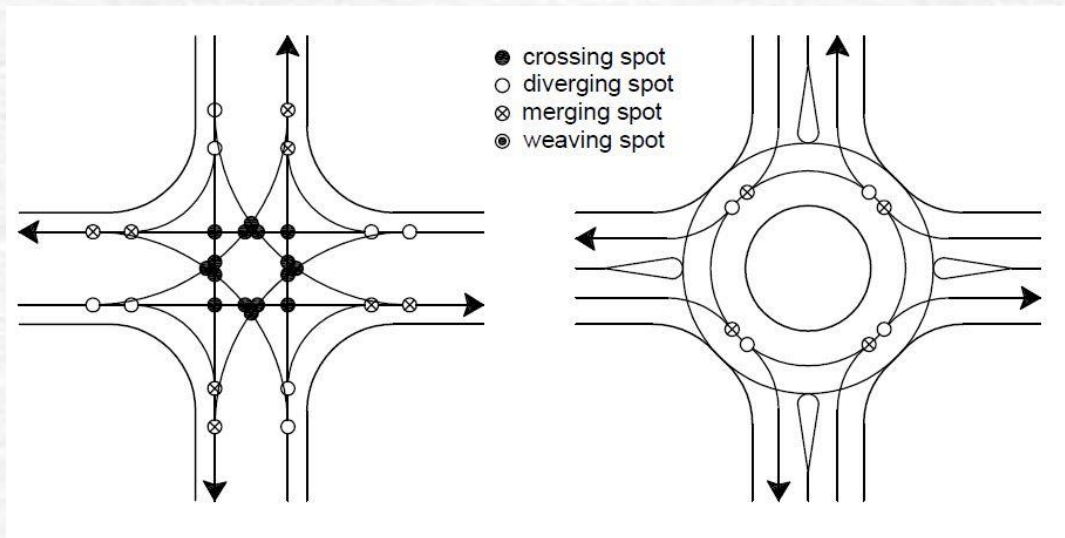


PROBLEMS IN MULTI-LANE ROUNDABOUTS

“CLASSIC” INTERSECTION vs. ONE-LANE ROUNDABOUT

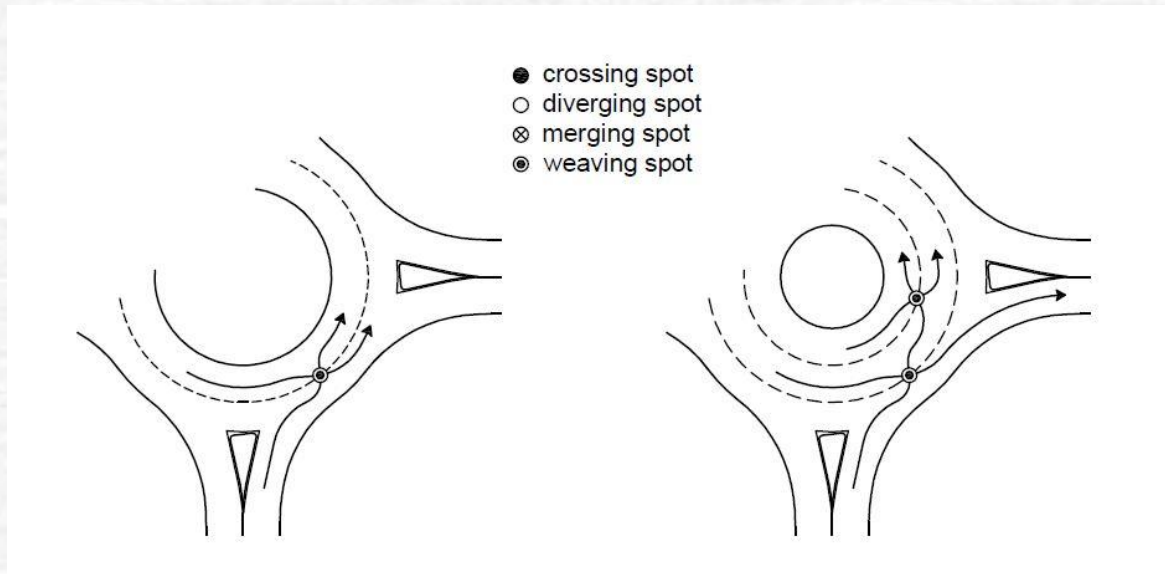
The main advantage of the one-lane roundabout, compared to “classic” intersection, is the elimination of conflict spots of the first (crossing) and second (weaving) level and the reduction of conflict spots of the third level (merging, diverging).

Theoretically, the classic four-arm intersection has 32 conflict spots (16 crossing, 8 merging and 8 diverging), while the one-lane four-arm roundabout has only 8 conflict spots of a lower level (4 merging and 4 diverging).



MULTI-LANE ROUNDABOUT

If there are two circular lanes in the roundabout, the number of conflict spots increases for the number of weaving conflict spots, which theoretically equals the number of arms, however this number is still lower than 32.



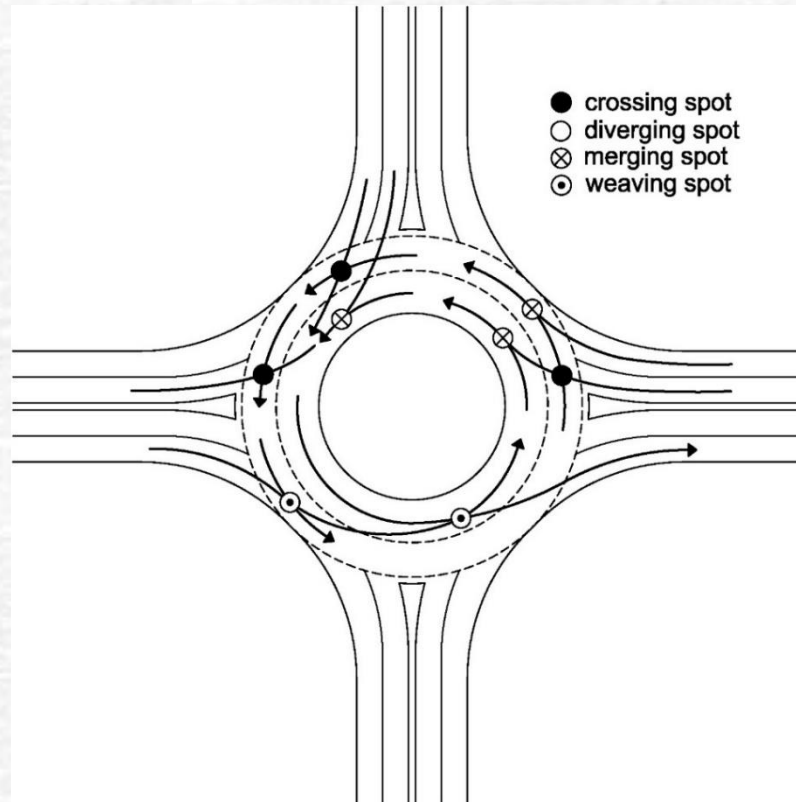
Conflict spots in the multilane roundabouts with one entry lane

But, from the practical point of view, we are not only speaking of conflict spots in the multilane roundabouts, but also of conflict sections (sequence of conflict spots), since there is no predetermined spot for drivers, where they must change the lane in the circulatory carriageway.

In multilane roundabouts with two-lane entries and exits, the traffic-safety conditions are even a little bit worse!!!

In this case, there are conflicts at the point of crossing the circulating lanes at the entry and even bigger, in the course of changing the traffic lane in the circulatory carriageway. However, by far most dangerous is the manoeuvre of leaving the roundabout from inner circulatory lane!!!

Consequently: Alternative types of roundabouts!



What does it mean alternative types of roundabout (from Slovenian point of view)?

The alternative types of roundabouts are usually more recent, and implemented only in certain countries!

It is typical for them that they differ from "classic" (or standard) roundabouts in one or more design elements, while the purpose of their implementation is also specific.

Why the alternative roundabout types?

Especially because of:

- particular disadvantages of "standard" one- or two-lane roundabouts in particular actual circumstances,
- changes of "actual circumstances" which in past lead to roundabout implementation.

Alternative types of roundabouts can be divided into three groups

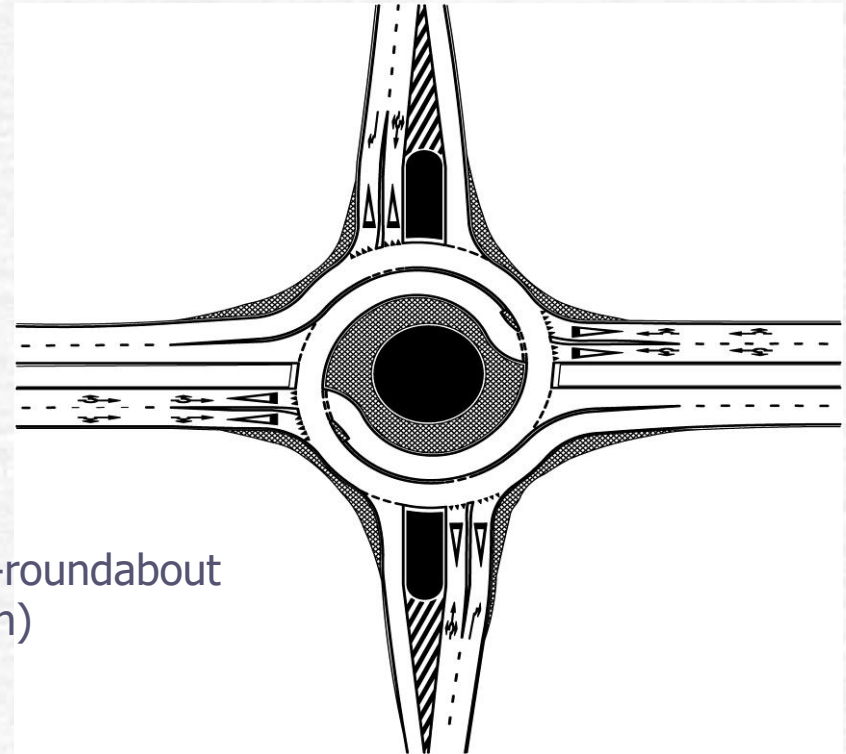
Alternative types of roundabouts which are:

- ❑ already in frequent use all over the world (e.g. assembled, hamburger, dumb-bell ...),**
- ❑ recent and have only been implemented within certain countries (e.g. mini, neighbourhood traffic circle, turbo roundabout, dog-bone, compact semi-two-lane, traffic signal controlled roundabouts ...),**
- ❑ still at the development phase (e.g. turbo-square, flower, target, four fly-over roundabout...).**

Definition of the turbo roundabout

Canalized multilane oval at-grade intersection with a non-traversable or partially traversable central island and with a spiral circulatory carriageway, where into three or four roads enter, with four centres of outer and inner diameters and traffic lanes (spiral course of the carriageway)

Turbo roundabout is an innovative arrangement of the two lane roundabout that has revolutionised roundabout design in The Netherlands and some other countries. The turbo roundabout is a specific kind of spiralling roundabout that was developed by dr. B. Fortuijn. Turbo roundabout is a special type of two lane roundabout, where some direction flows are separated or run on physically separated lanes.



the origin of the turbo-roundabout
(source: Bertus Fortuijn)

Physical separation is achieved by specially shaped elements - curbs, which hinder (but not prevent) the change of traffic lanes in the turbo roundabout



Conditions and locations of appropriate use – Slovenian experiences

Turbo roundabout is an appropriate solution on locations outside the urban areas, when there is normally one main and one side traffic route, regarding the intensity of the traffic flows.

Turbo roundabout in the urban area is just a conditionally appropriate solution.

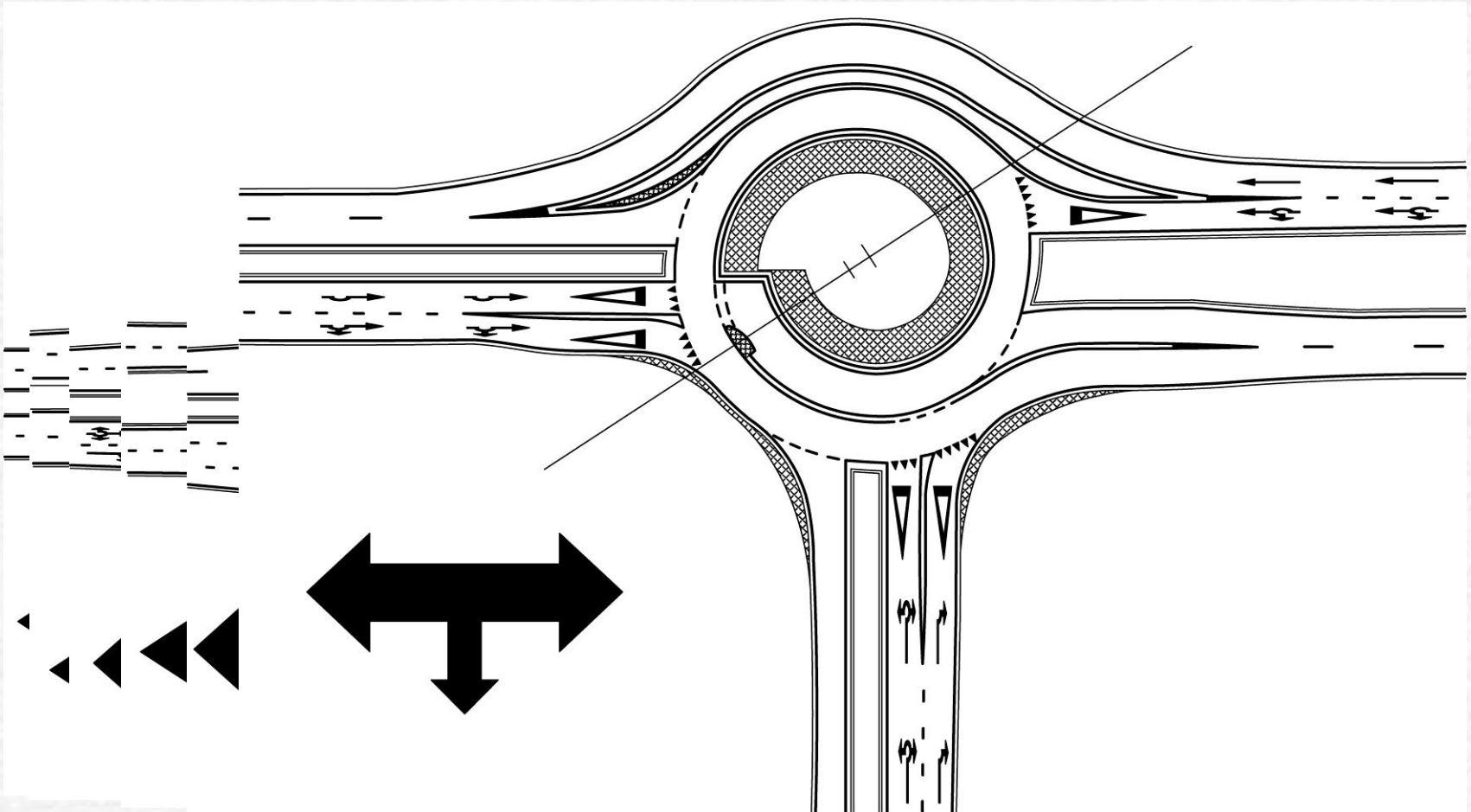
If a roundabout with two entry and two exit lanes is considered, which would be located in the urban area, we must first solve the problem of traffic-safe leading of non-motorized participants!!!

Turbo roundabout is a conditionally appropriate solution in the case of:

- existing traffic-overloaded one-lane roundabouts, the size of which (outer radius) enables the implementation of an additional circulatory lane inwards (better solution) or there is space for the implementation of another circulatory lane outwards (somewhat less appealing and more expensive solution),
- existing traffic-overloaded two-lane roundabouts,
- existing traffic less safe two-lane roundabouts,
- reconstruction of the classic intersection with a predominant main traffic direction, with a very strong traffic flow.

In all these cases, the selection of the type of the turbo roundabout also depends on the predominant direction of the main traffic flow.

Namely, the predominant direction of the main traffic flow is the criterion for the selection of the type of the turbo roundabout:



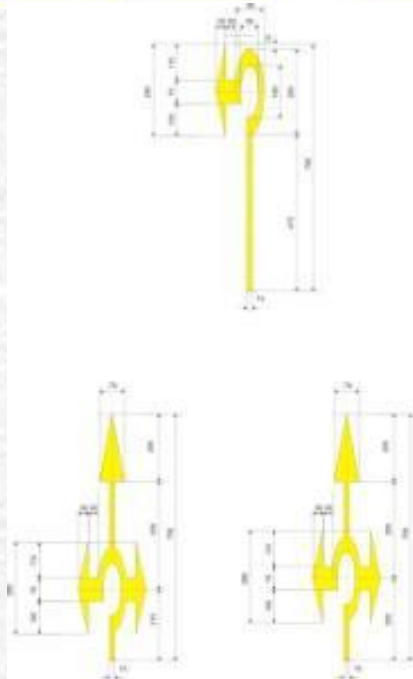
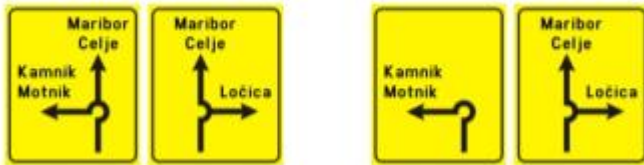
The turbo roundabout has a larger capacity, compared to the “standard” two-lane roundabout. There are several reasons for that:

- at the roundabout entry of this type, there are usually two traffic lanes, which directly continue into two circulatory traffic lanes,
- the use of the inner circulatory traffic lane becomes more attractive - no need for weaving,
- the entry traffic flow is no longer hesitant, when entering the circulatory carriageway, which increases the capacity of entries.



TRAFFIC SIGNS, SIGNPOSTINGS AND ROAD MARKINGS

- the traffic signalisation is extremely important in those type of roundabouts
- specific signposting and specific road markings (arrows)

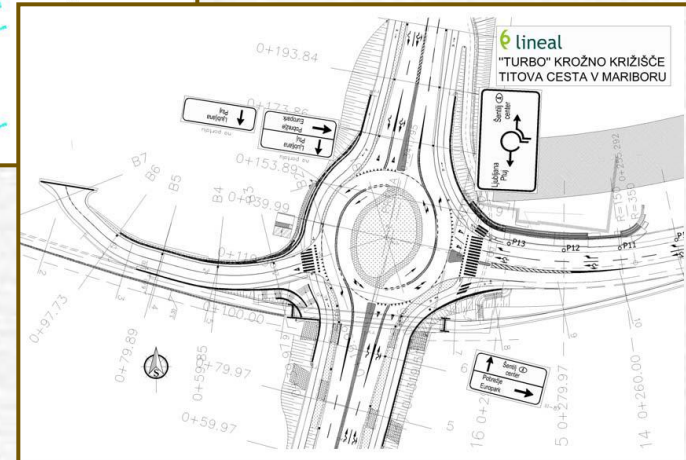
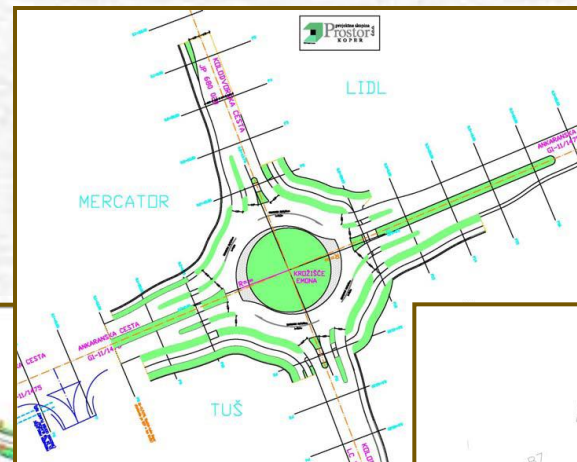


Slovenian experiences with turbo – roundabouts

Idea transfer to Slovenia very fast!

Reasons:

- insufficient use of inner circulatory lane
- traffic habits and (un)culture
- too small double-lane roundabouts were build in the past
- low traffic safety level of "standard" multi-lane roundabouts
- year 2006 – first ideas of implementing turbo roundabouts



About introduction process

Without knowledge, without experiences, without literature ... !

Procedure:

- detail exist literature analysing (most were the Netherland's)! ;-)
- two visits in South Netherlands and site examination of about 20 achieved examples,
- for implemented examples we acquire design documentation from colleagues on MTW,
- exchange opinion with turbo-roundabout's father dr. B. Fortuijn



Slovenian experiences with Turbo Roundabouts 1/6

- process started at 2006,
- we encounter specific problems because of the weather conditions (cleaning the snow from the turbo roundabout), but we found good solution.



Traffic safety analysis of Slovenian turbo roundabouts

- ❑ November 2013: Traffic safety analysis of Slovenian turbo roundabouts
- ❑ The analysis covered only those turbo roundabouts that were built by reconstruction of previous intersections into turbo roundabouts. Therefore, the analysis did not cover the turbo roundabouts built on the locations where no intersections had existed in the past.



☐ Accidents:

- In general, turbo roundabouts in Slovenia have met the expectations – as concerns the large capacity and particularly the high level of traffic safety.
- It needs to be stressed 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 occurred.

☐ Driver's opinion: In driver's opinion, this type of roundabout is very safe due to the reasons:

- driver is all the time in his "own" lane,
- 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 "standard" multi-line roundabouts,
- signposts and road markings are easily understood and unmistakable.

Slovenian experiences with Turbo Roundabouts 4/6

- we do not have any problems (because of rised curb on cc) with motorcyclists!



Slovenian experiences with Turbo Roundabouts

5/6

- certain dimensions of the Netherlands's typical turbo roundabout were also changed in order to suit the Slovenian conditions.
- The Slovenian typical turbo differs from the Netherlands:
 - Slovenian turbo is smaller,
 - separation of entry/exit traffic lanes with intermediate splitter islands,
 - usually without "peaks",
 - different design of the entrance to the inner circulatory lane



- microsimulations of achieved site examples (animations and visualizations) for mathematical model's calibration (first of all because of the capacity),
- corrections and complement of the new version of Slovenian guidelines for turbo – roundabouts,
- we resigned to achieve "standard" two- and three- lane roundabouts (not safe enough taking into account our driving habits)!!!

**” STANDARD” TWO-LANE ROUNDABOUTS ARE NOT
ALLOWED IN SLOVENIA ANYMORE!!!
(from 2010)**

At the moment

15 TR, 2 under construction



Two of them are assembled turbo roundabouts ...



... and one of them is 4-lane traffic-signal controlled

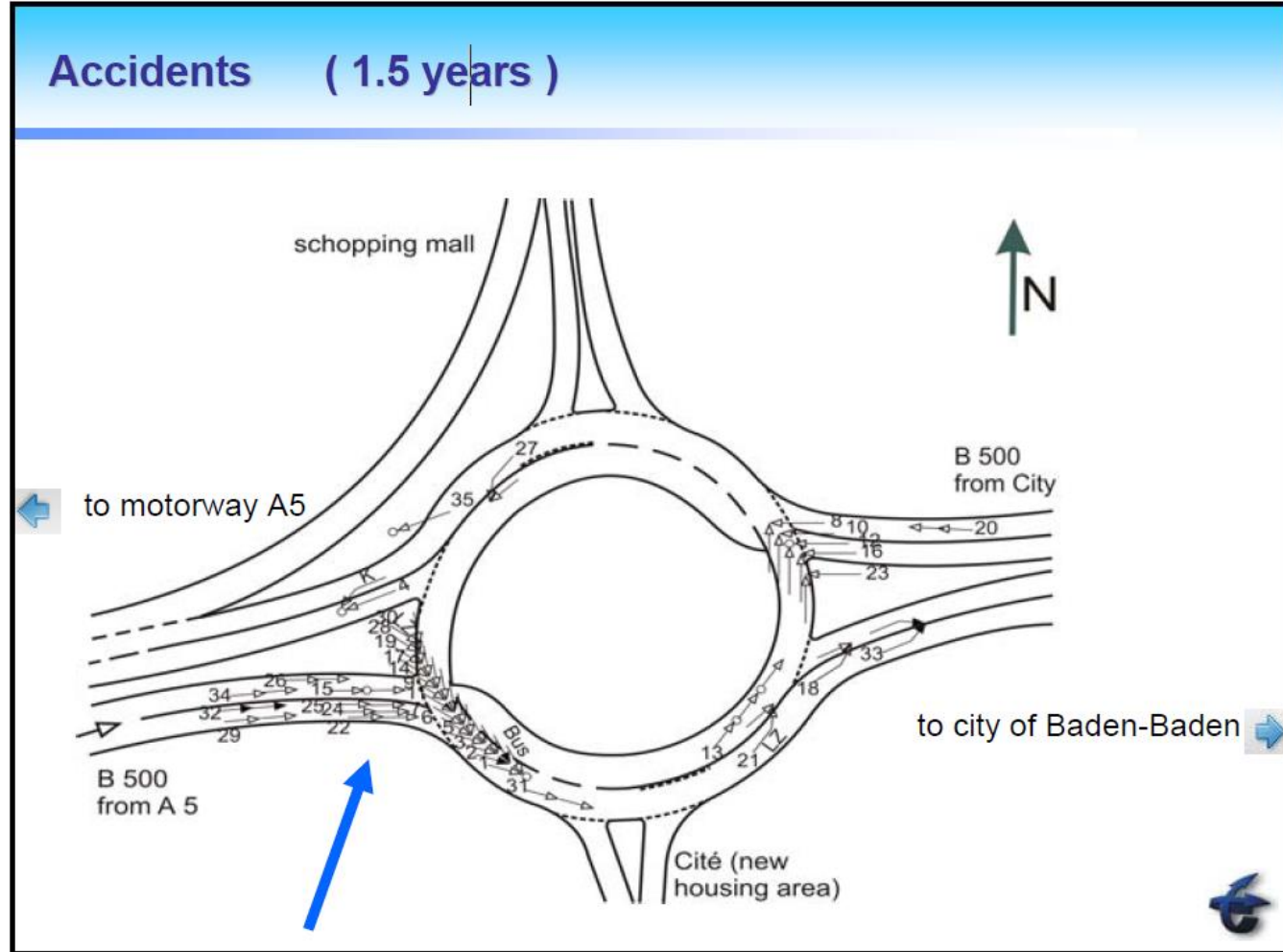


Lessons learned

or

**What we have learned about turbo roundabouts –
worldwide experiences?**

- ❑ Germany: Baden Württemberg (no curbs, just painted – bad experiences)



source: Werner Brilon

❑ Czech Republic: Brno, Olomouc (bad experiences)



source: Martin Smělý

- ☐ Hungary: city Szolnok; from 2009; too much divided curbs – bad experiences!



source: Irena Ištoka Otković

- ❑ FYR of Macedonia: city of Skopje, 2011, very good experience, although...



- ❑ Lithuania and Canada: with milled noise strips; no traffic safety data



source: Saulius Vingrys



source: Tim Murphy

At the moment, several research works are running on the development on different layouts of roundabouts for different circumstances or problems.

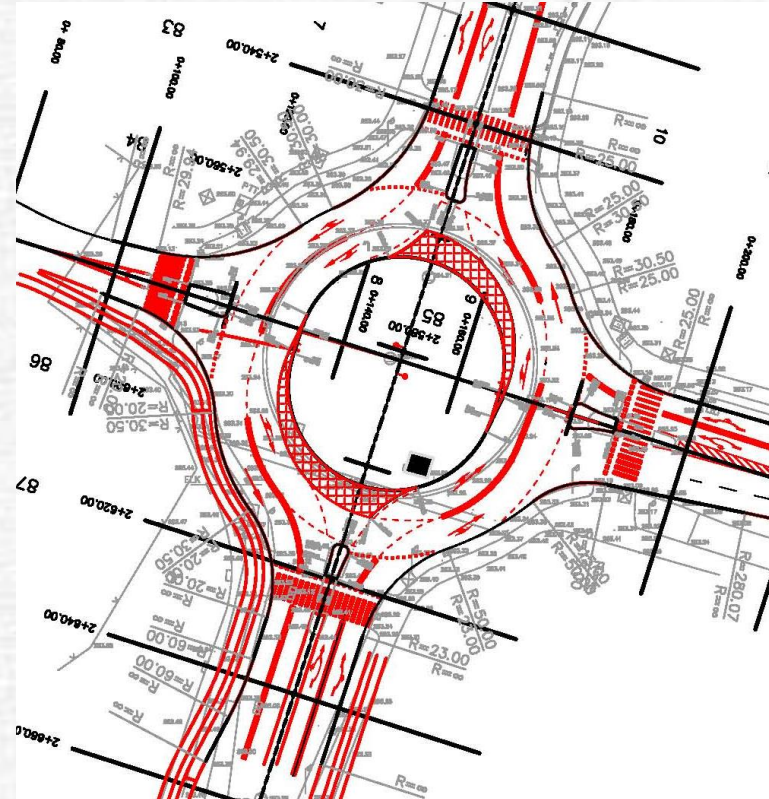
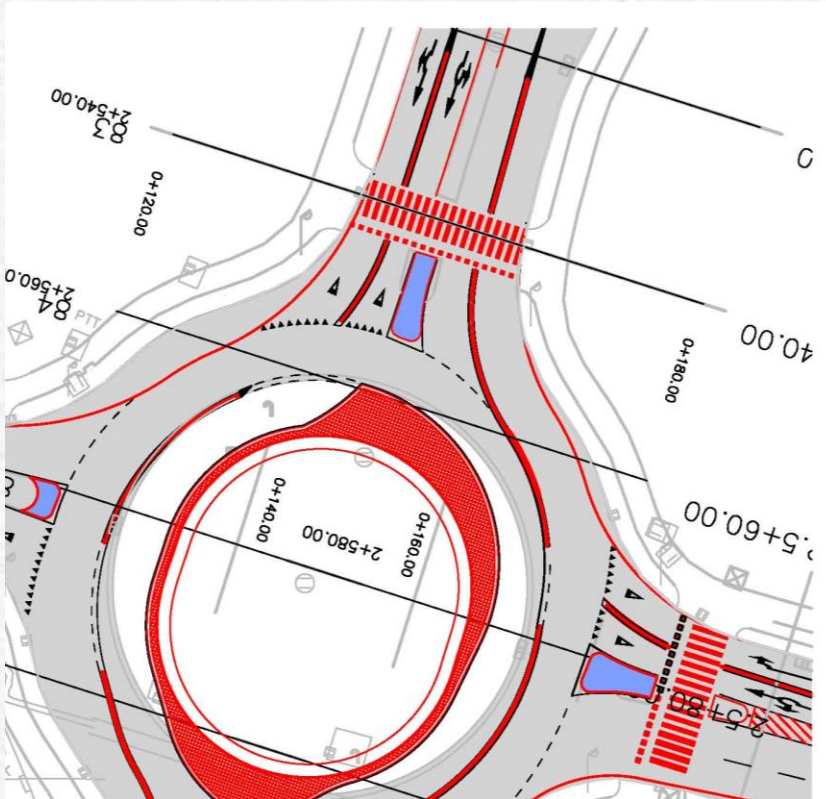
Also in Slovenia!!!

All alternative types of roundabouts, presented in continuation, were invented at University of Maribor, Faculty of Civil Engineering, Transportation Engineering and Architecture (and two of them are also patented).

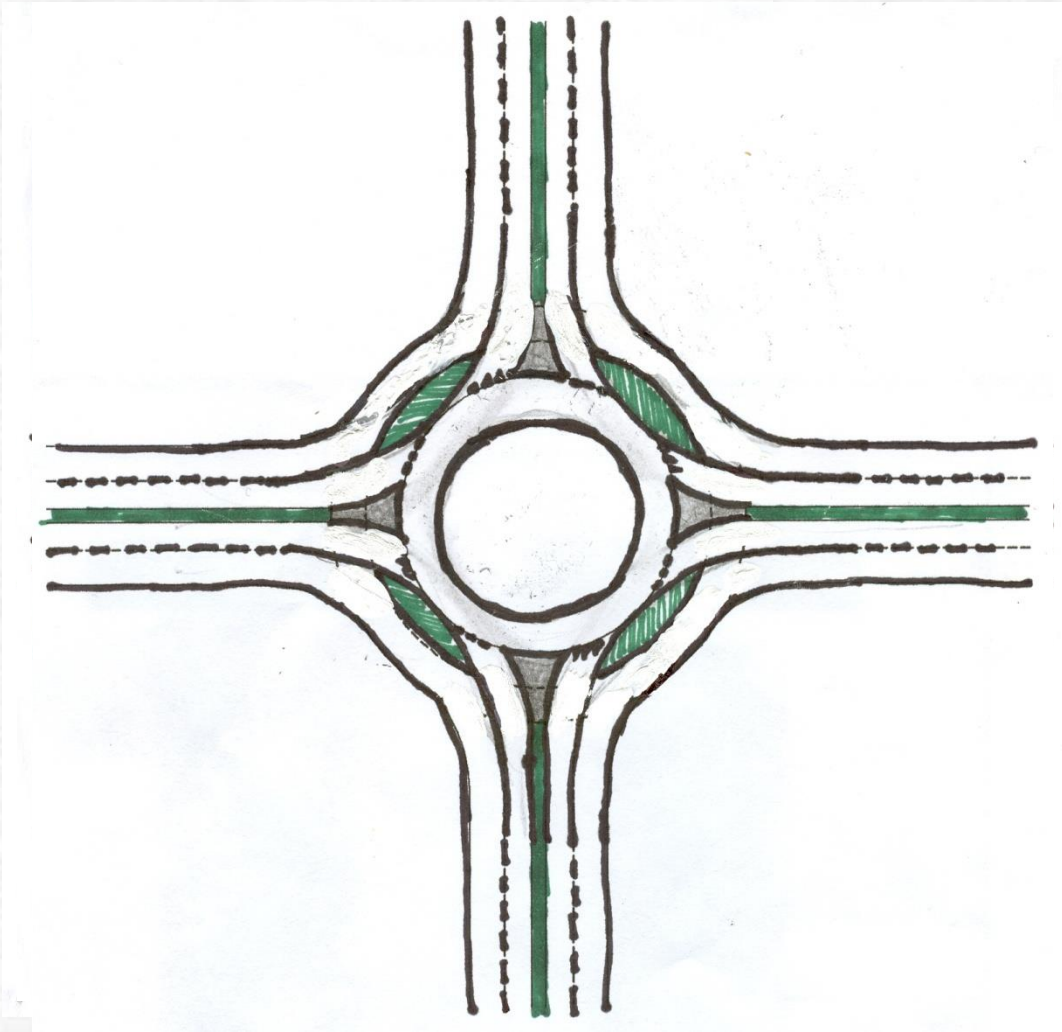
The idea of flower-roundabout

What to do with the existing (less-safe) standard two-lane roundabouts?

It would be an illusion to expect (mostly for financial reasons) that they could all be reconstructed into the turbo roundabouts!

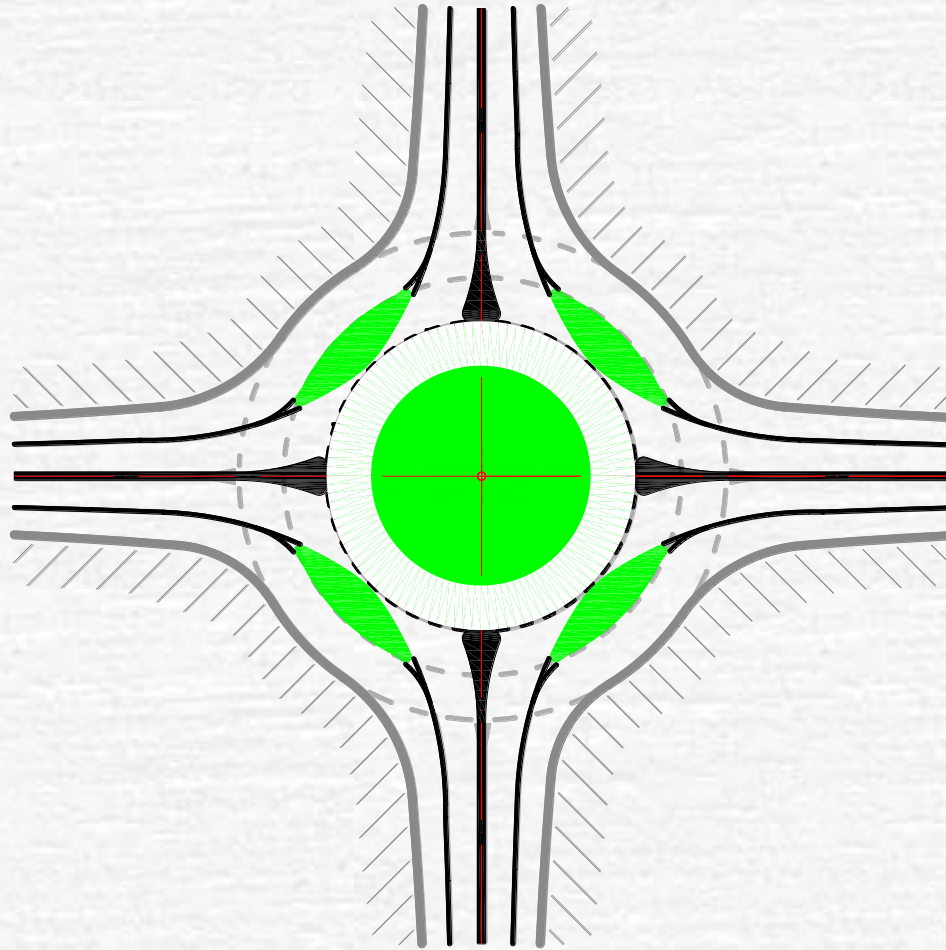


We tried different solutions ...



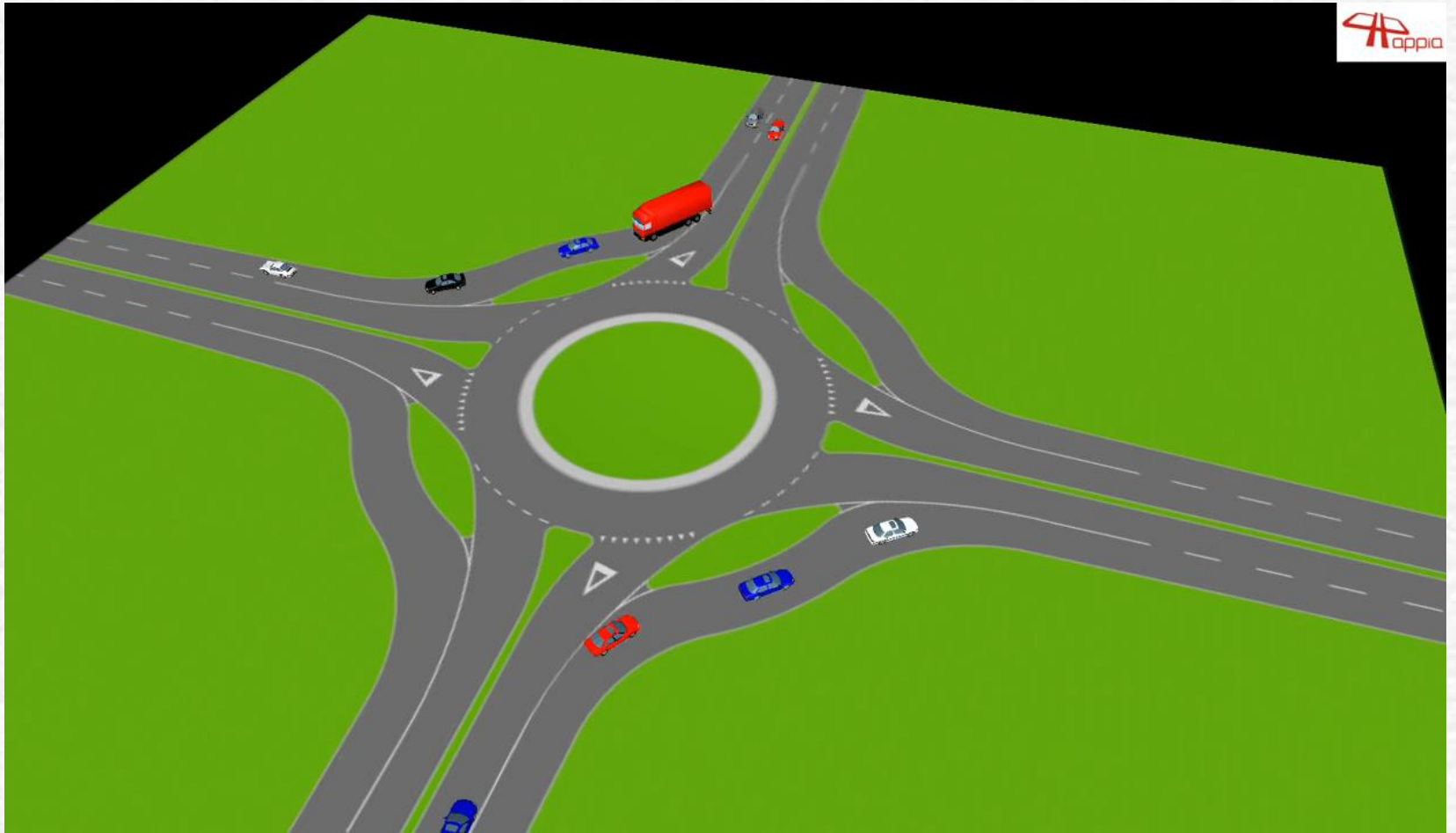
roundabout with "pushed" ("depressed") lanes for right – turning; shortly "flower-roundabout"

At the reconstruction of the "standard" two-lane roundabout into the flower-roundabout, all the outer road curbs of the circulatory carriageway, splitter islands, public lighting poles ... remain on the same position.



How it works:

<http://www.youtube.com/watch?v=TrUQNd9rOAo>





Na podlagi prvega odstavka 90. člena Zakona o industrijski lastnini (Uradni list RS, št. 51/2006 - uradno prečiščeno besedilo, v nadaljnjem besedilu: zakon) in prijaviteljeve zahteve za podelitev patenta izdaja Urad RS za intelektualno lastnino

ODLOČBO O PODELITVI PATENTA

Podeli se
PATENT

Številka
23266

Imetnik:

Univerza v Mariboru, Fakulteta za gradbeništvo,
Smetanova 17, 2000 Maribor, Slovenija

Izumitelj:

Tollazzi Tomaž 2000 Maribor, Slovenija;
Renčelj Marko, 2000 Maribor, Slovenija;
Sašo Turnšek, 2000 Maribor, Slovenija;
Goran Jovanović, 2000 Maribor, Slovenija

Naziv izuma:

Krožno križišče s pritisnjenimi pasovi za desno zavijanje

Prijavitelj:

Univerza v Mariboru, Fakulteta za gradbeništvo,
Smetanova 17, 2000 Maribor, Slovenija

Številka prijave:

P-201000026

Datum vložitve prijave:

28.01.2010

Zahtevana prednostna pravica:

Razvrstitev po mednarodni klasifikaciji patentov:

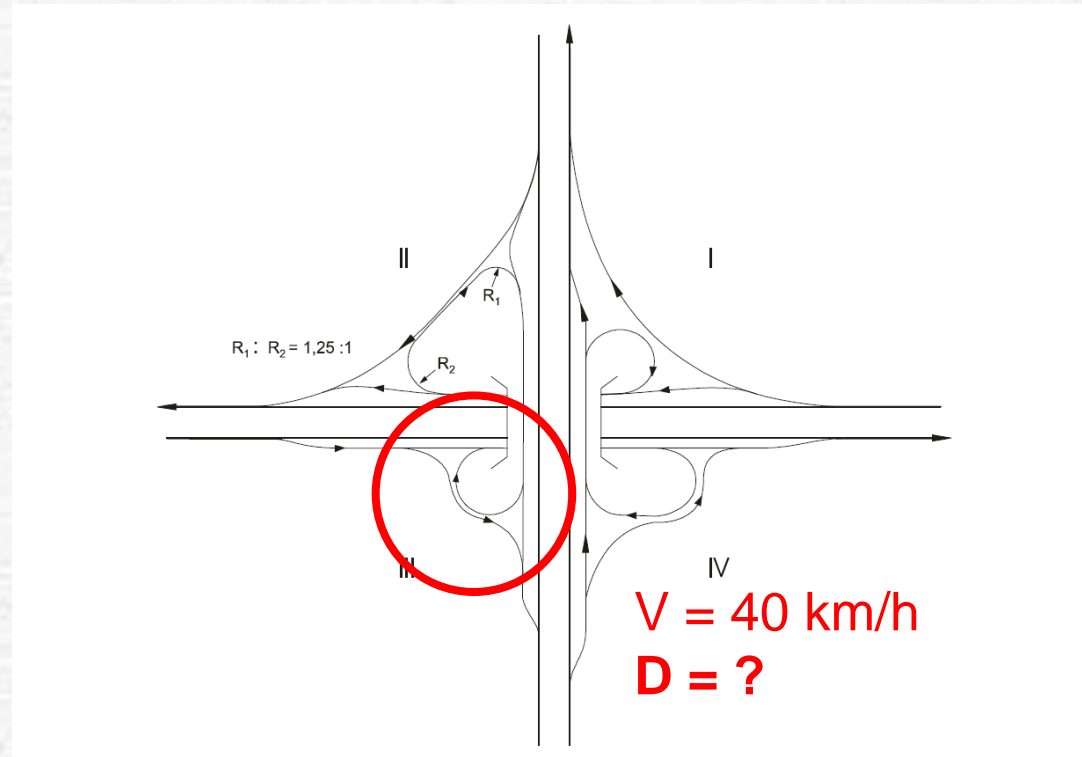
E01C 1/00

Datum objave prijave:

29.07.2011

The idea of the "target-roundabout":

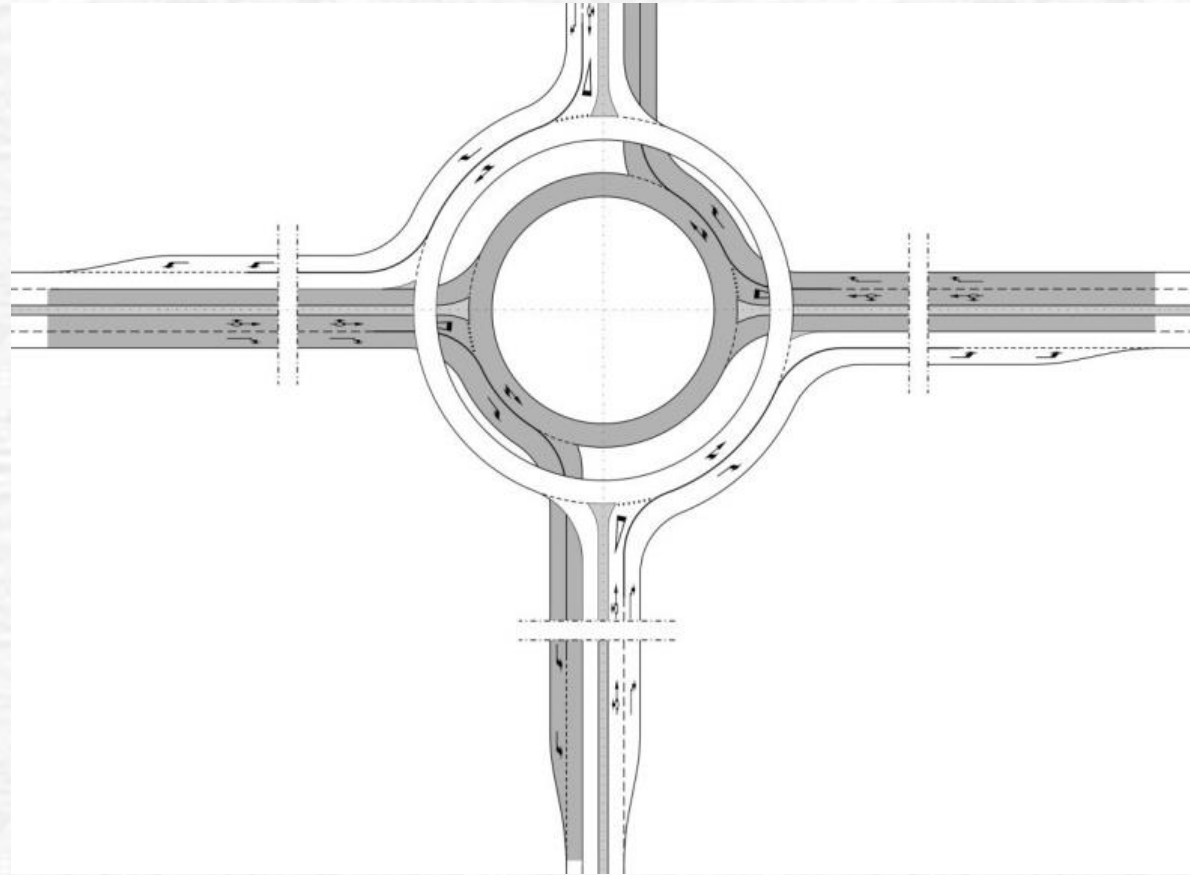
If we need to design an intersection of two four-lane roads ("full intersection" – from all ways to all ways) standard solution is "cloverleaf" – one of the four combinations



But: For this solution we need a lot of space (a lot of land = a lot of money and a lot of problems with ministry of environment, agriculture ...)!

... another (a new) solution could be a "two levels one lane roundabouts with depressed lanes for right turners" – shortly "target-roundabout"

The "target-roundabout" is presently also at the development phase (and also patented)!



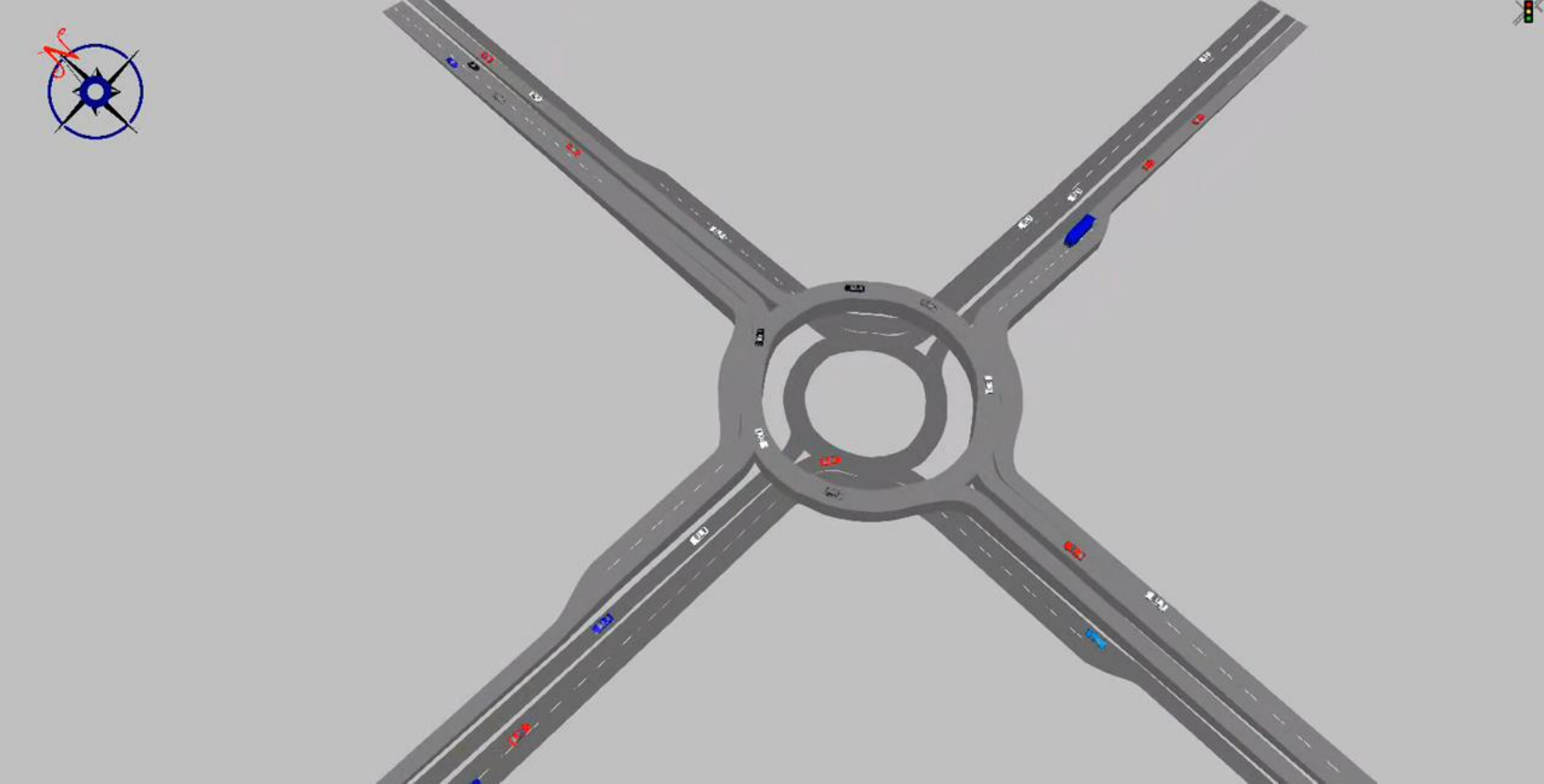
A target-roundabout is designed as a two one-lane roundabout with different outer diameters, located on dual levels, and all right-hand turners on both roundabouts have their own, separate right-hand turn bypass lanes.

2.23 Patent application

334. TOLLAZZI, Tomaž, RENČELJ, Marko, TURNŠEK, Sašo. *Enopasovni krožni križišči v dveh nivojih z ločenimi pasovi za desne zavijalce : patentna prijava št. P-201300087, 4. 4. 2013.* Ljubljana: Urad RS za intelektualno lastnino, 2013. [6] str. [COBISS.SI-ID [16821526](#)]

How it works:

<http://www.youtube.com/watch?v=FP9AuAtdXDw&feature=youtu.be>

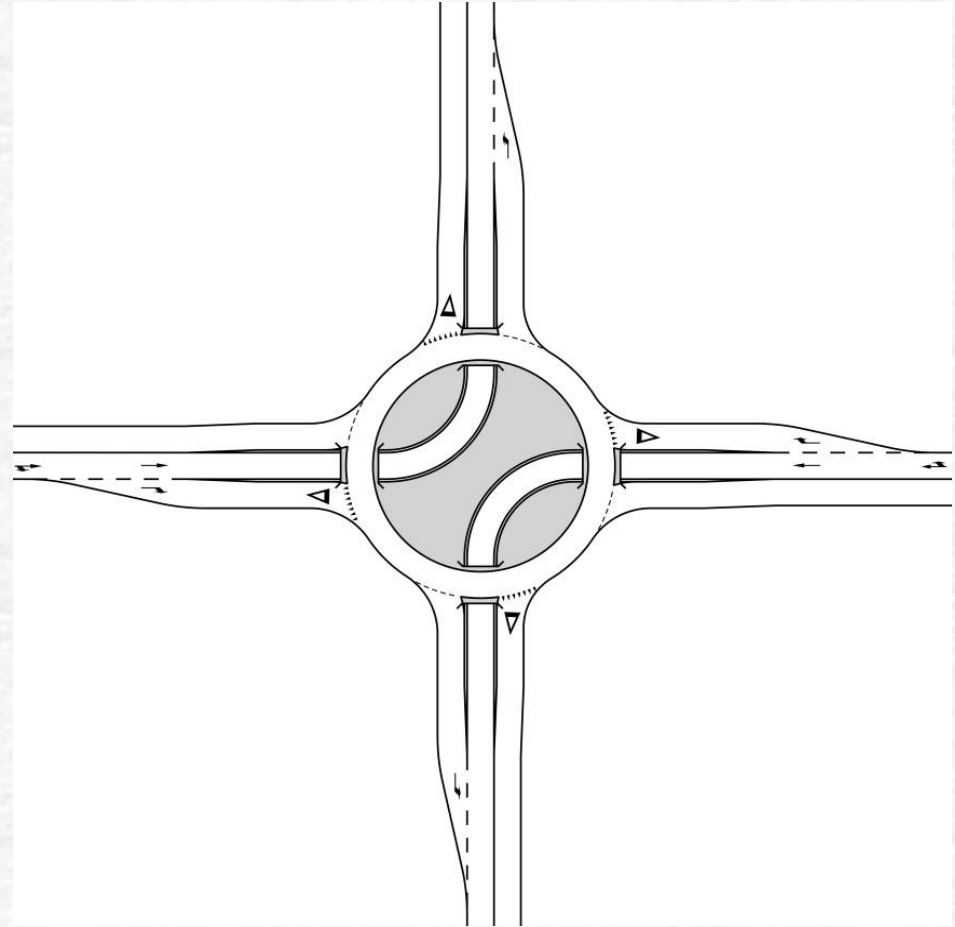


The idea of the "four-flyover roundabout":

The roundabout with segregated left-hand turning bypasses (slip-lanes) on major roads – in short the "four-flyover roundabout" is at the moment also at the development phase - and in patented process.

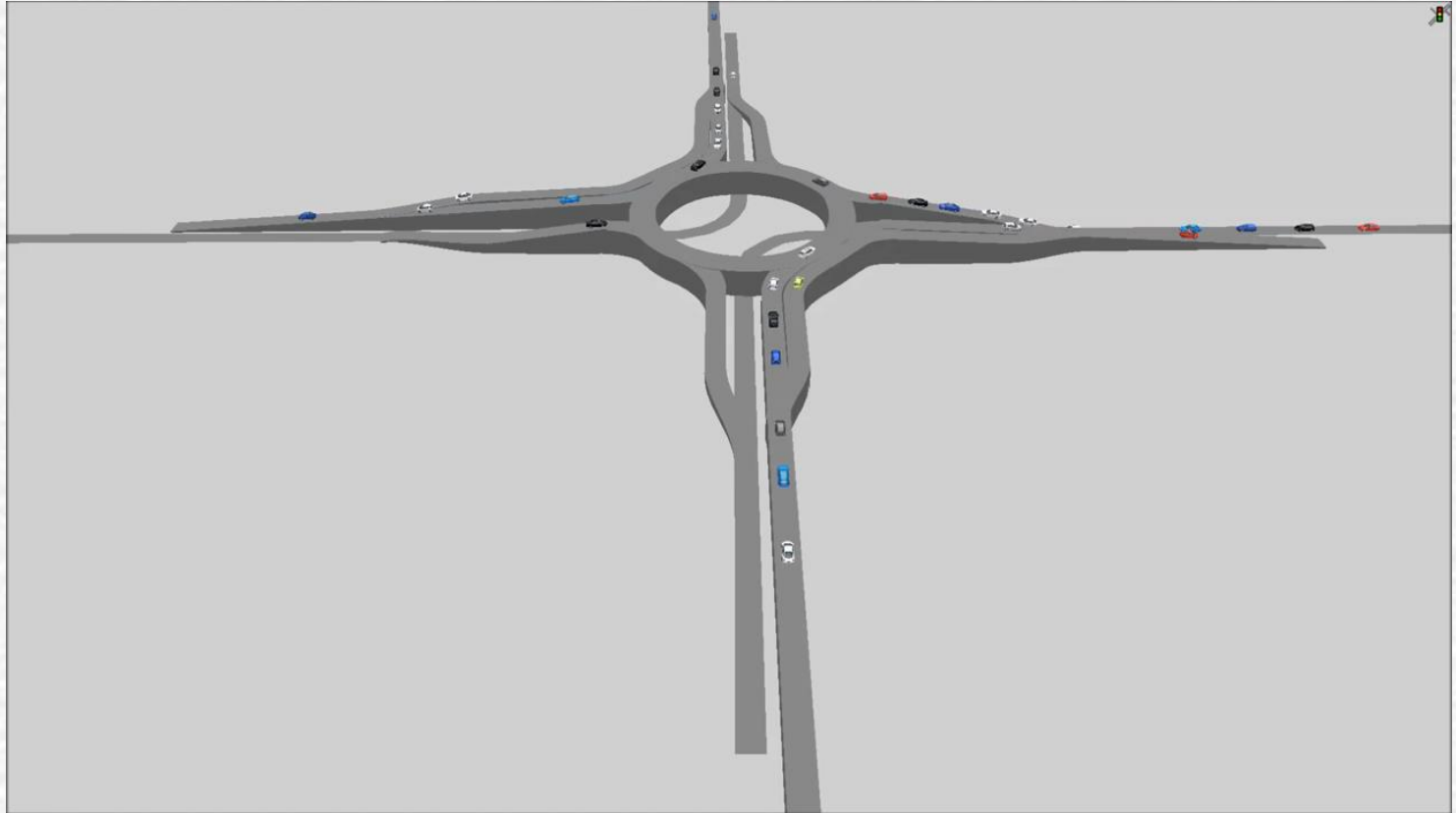
It is designed as a one large one-lane roundabout at upper, and both left-hand turners on the major roads have their own separate left-hand turn bypass lanes, located at another, lower level.

Left-hand turners are located as on standard intersections – at the left lane on the approach.



How it works:

<https://www.youtube.com/watch?v=XoDF6nqmzdl>



CONCLUSION

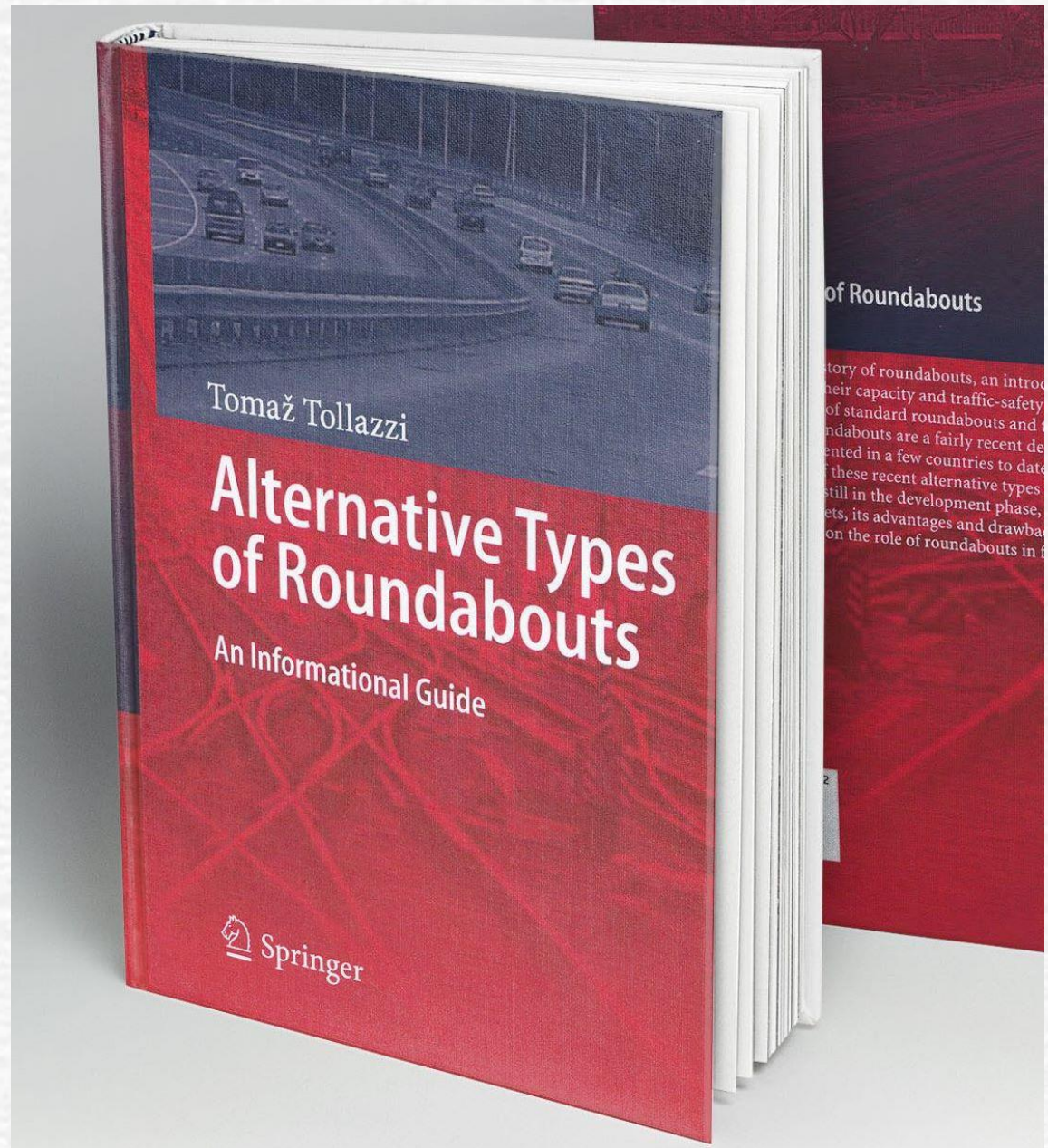
In many European countries research into the various aspects and various types of roundabouts as useful types of road intersections has spanned many decades.

All alternative types of roundabouts have their advantages and deficiencies, which makes sense, as they are intended to solve particular problems. In the near future, we can expect further developments of alternative types of roundabouts, intended for solving specific problems, which will certainly represent a challenge to our branch of science.

At the moment, several research aspects are running on the development on different layouts of roundabouts for different circumstances or problems.

Also in Slovenia!

... and if you are interesting to ...





Prof. Tomaž Tollazzi, Ph.D.

tomaz.tollazzi@um.si

University of Maribor
Faculty of Civil Engineering,
Transportation Engineering and
Architecture

<http://izumbib.izum.si/bibliografije/Y20171201192110-A3381347.html>