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Alternative types of roundabouts at the development phase

Alternative types of roundabouts can be divided into three groups:

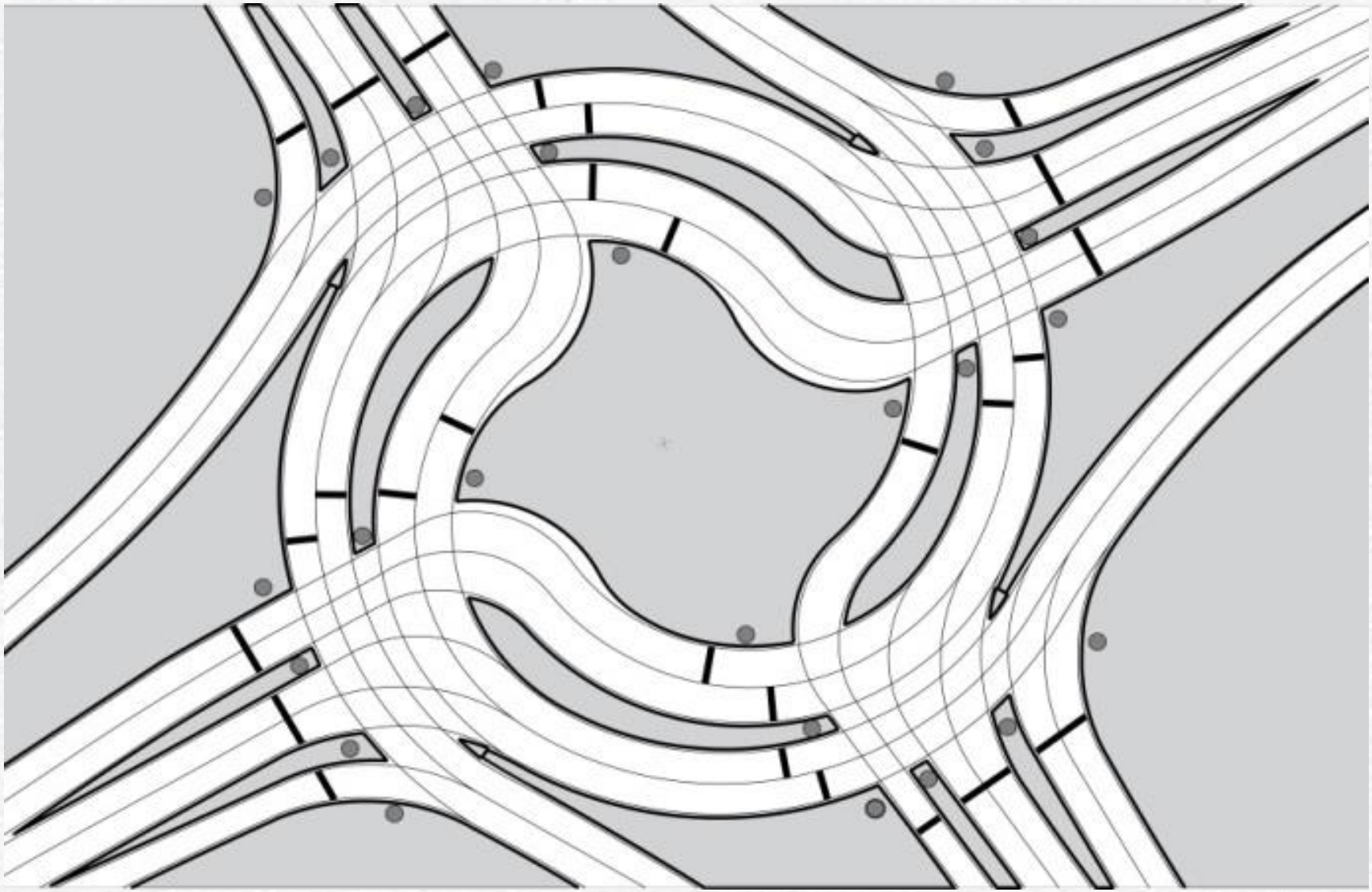
- **already in frequent use all over the world**
- **recent and have only been implemented within certain countries,**
- **still at the development phase.**

Some of them are:

- **turbo-square,**
- **flower-roundabout,**
- **target-roundabout,**
- **roundabout with segregated left-turn slip-lanes (”four flyover roundabout”),**
- **”left-and-right roundabout”.**

In 2000, the Province of Zuid-Holland has introduced the signalized multi-lane **''turbo-square''** (in original ''turbo-plein'') as a new intersection layout and has installed two of them near Delft (today three of them exist).

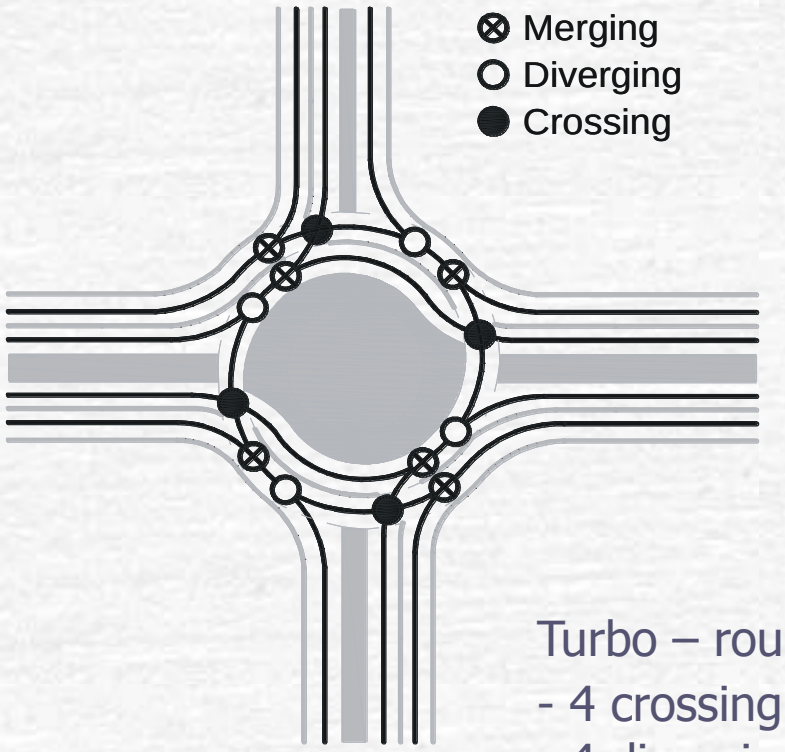
The signalized multi-lane turbo square is an at-grade solution with a large traffic throughput capacity, based on the principle of a turbo-roundabout with signalized traffic control.



The idea is that it fulfils the pre-conditions of a roundabout, namely the approach lanes are radials connected (this reduces the entering speed) and the traffic on the square has the right of way.

Besides, at a turbo-square there is sufficient space at the roundabout segments to buffer the left-turning and through-going traffic.

Introduction for the ”roundabout with depressed lanes for right turners - flower roundbout”



From traffic safety point of view, ”turbo” is most effective roundabout type (because no waiving conflict spots and because separated traffic lanes in circulatory carriageway)!

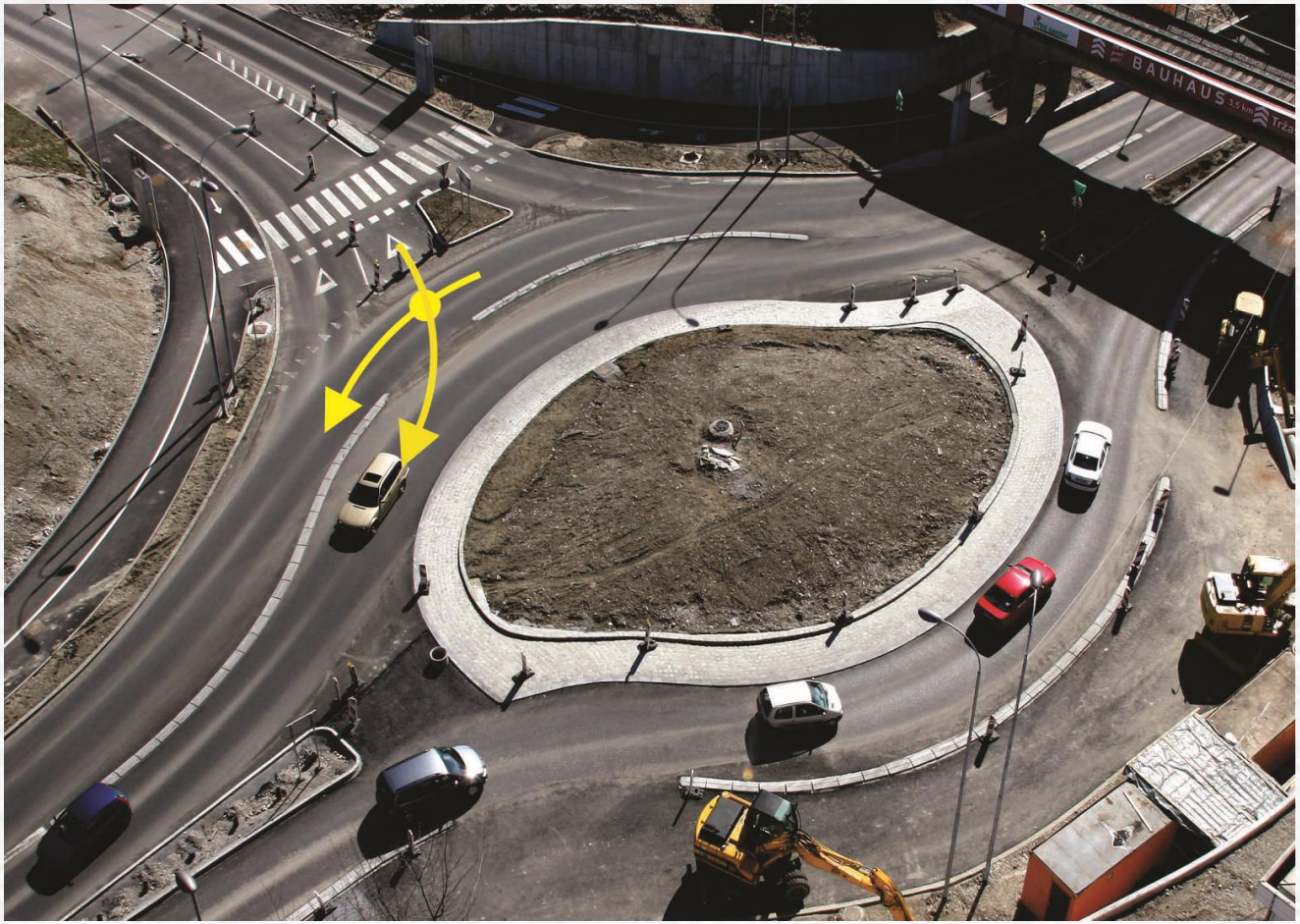
But, it also has disadvantages!!!

Turbo – roundabout disadvantages:

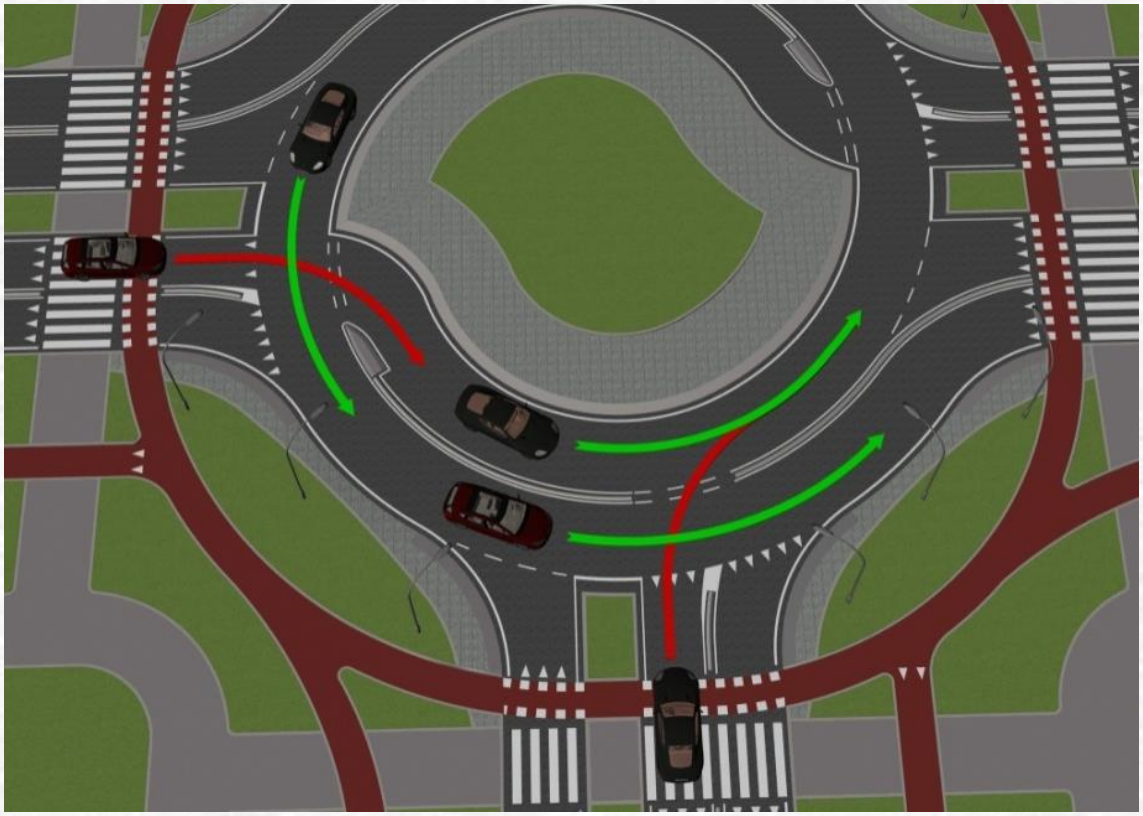
- 4 crossing spots
- 4 diverging spots
- 6 merging spots
- all traffic flows are ”pushed” to the circulatory carriageway

This is a theory, but …

… what does it mean in practice?



In two out of eleven Slovenian turbo roundabouts we notice confusion (insecurity) of drivers, when they enter the turbo roundabout on the inner circulatory lane!



The vehicle at this maneuver crosses a very strong traffic flow and enters the second, equally strong traffic flow, which causes a sense of insecurity and danger with the driver.

Therefore, these drivers enter the turbo roundabout very slowly or only when the vehicles in the cc are at a great distance from them.

Therefore, the crossing conflict points in the turbo roundabout have a significantly larger negative effect than was expected - at least at the beginning of the introduction – the greatest disadvantage due to Slovenian circumstances!

Notwithstanding the good general experience with the turbo roundabouts in Slovenia, the question is:

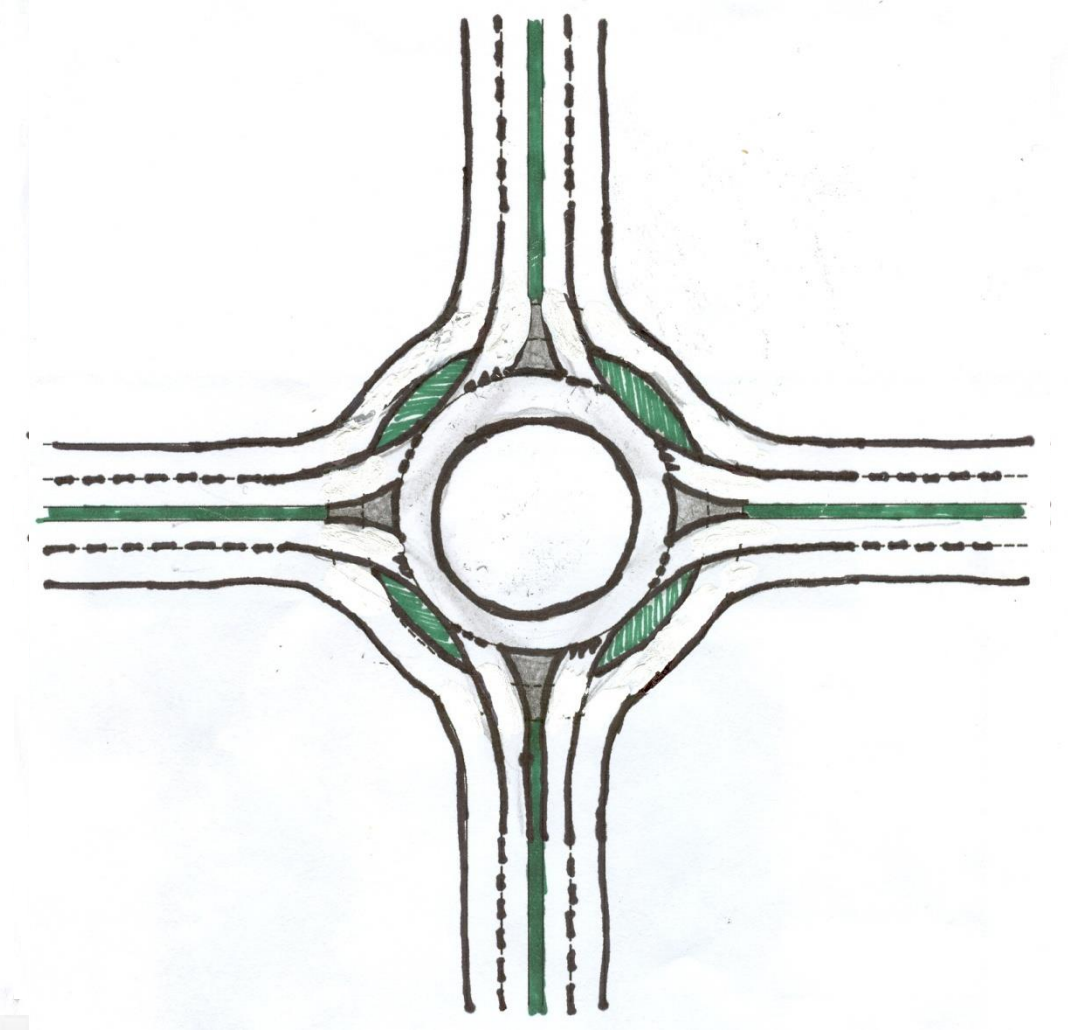
What to do with the existing, less safe, ”standard” multi-lane roundabouts?

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

There is a question, whether it is possible to combine positive characteristics of different types of roundabouts, while at the same time eliminating their negative characteristics or:

Is it possible to eliminate crossing and weaving conflict points in the existing ”standard” two- and three- lane roundabouts and thereby achieving a high level of traffic safety without decreasing the roundabout's capacity?

We tried with different solutions ...

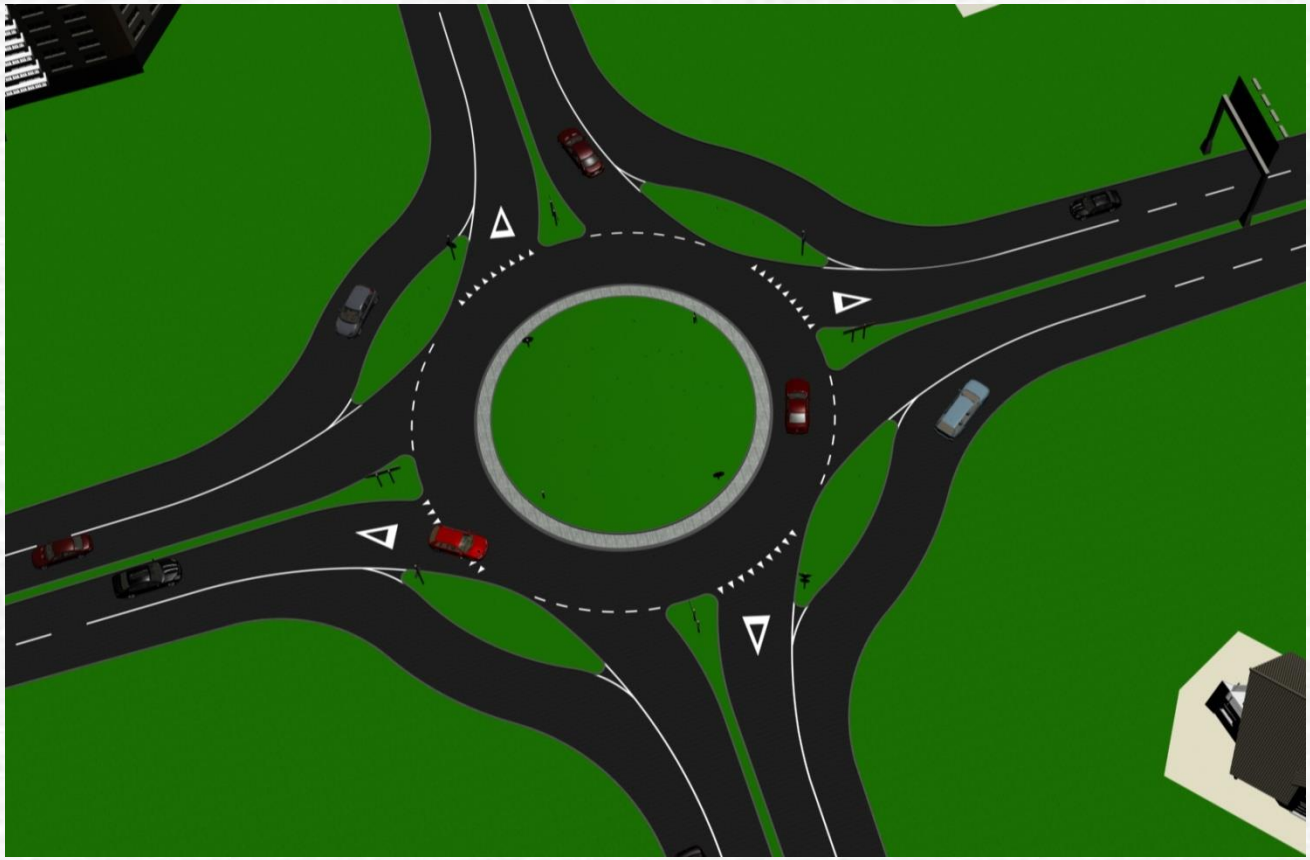


roundabout with ”pushed” (”depressed”) lanes for right – turning; shortly ”flower–roundabout”

Characteristics of flower – roundabout 1/4

One of the basic characteristics of the flower roundabout (the same as in the turbo roundabout) – physically separated traffic lanes in the circulatory carriageway.

The second characteristic is that the right-turners have their own separated lanes (bypasses, which are in frequent use in Slovenia). This causes that the inner circulatory carriageway is used only by vehicles, which drive straight through (180˚), turn for three quarters of a circle (270˚) or turn semicircle (360º).



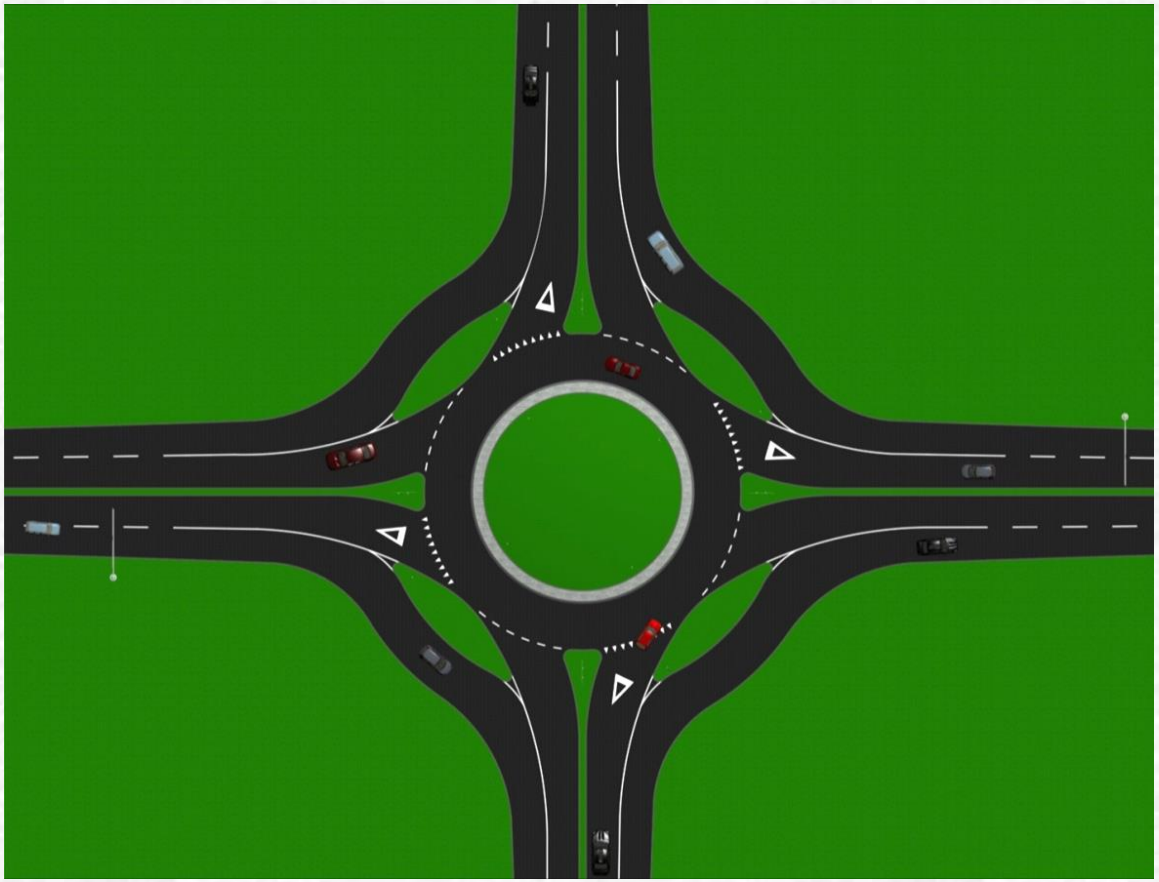
Characteristics of flower – roundabout 2/4

By physically separating the right turning traffic flow, we get a one-lane roundabout, where (unlike in the case of the turbo roundabout) there are no crossing conflict spots; however (unlike in the case of the “standard" two-lane roundabout), there are also no weaving conflict spots.

Weaving conflict spots transfer from the circulatory carriageway (in the curve) to the road section before the roundabout (usually a straight line), which is a safer solution from the traffic safety point of view.

Characteristics of flower – roundabout 3/4

From inner circulatory lane semicircle turning is possible (difference to turbo roundabout).
In cc there are no conflict spots of crossing or weaving (just 4 merging and 4 diverging).
Driving through flower – roundabout is like in ”normal” two-lane roundabouts.
This roundabout type ”forgive errors”: if driver mistakenly stays on left lane at the entrance it is still allowed to turn right on next exit.



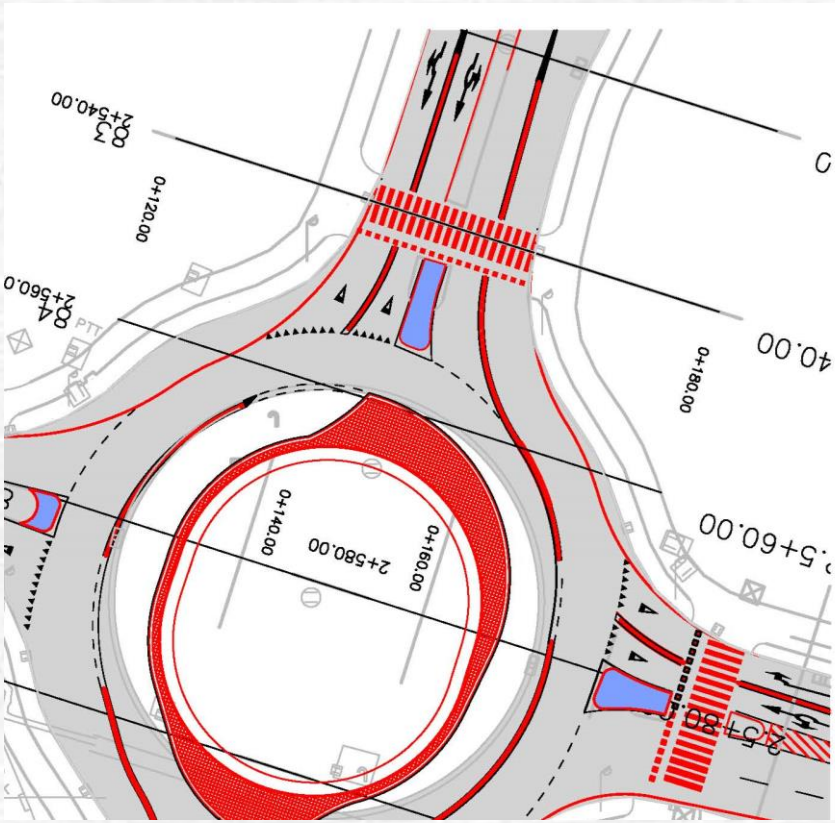
Characteristics of flower – roundabout 4/4

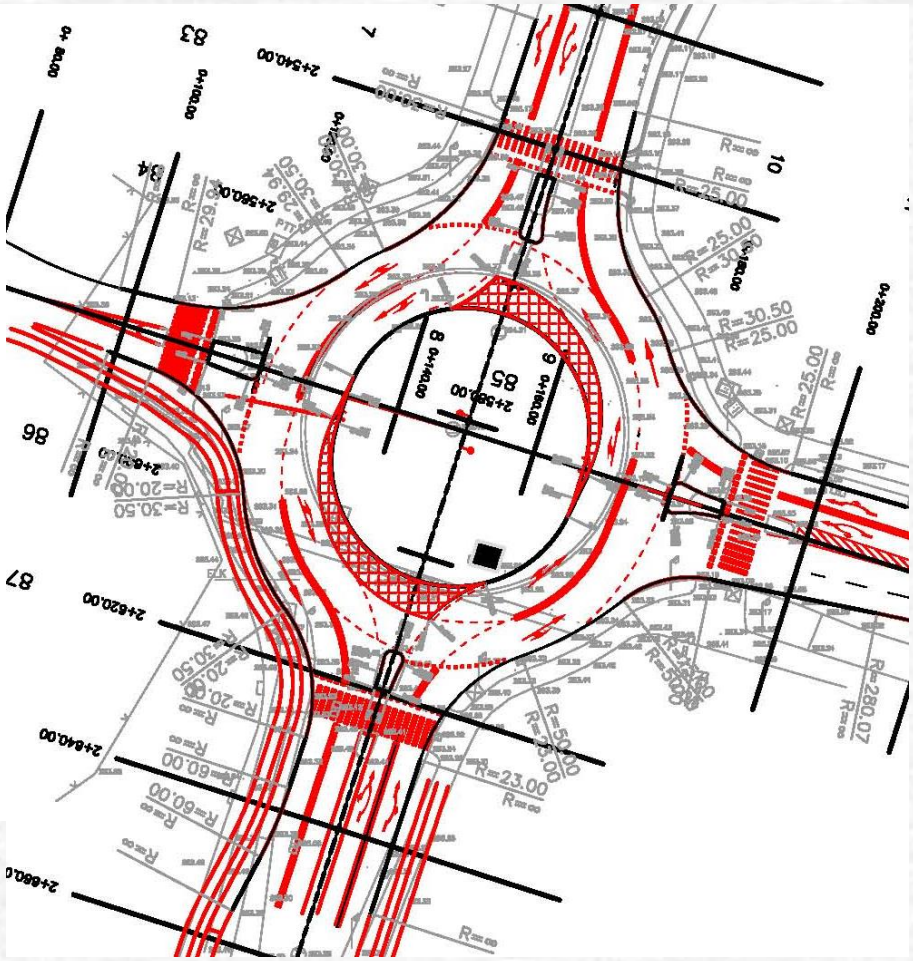
Probably the best characteristic of the flower roundabout - it is implemented within the existing ”normal” two-lane roundabout.

Therefore, bypasses are not novelty, they are in frequent use also in Slovenia (specialy two types of bypasses)!

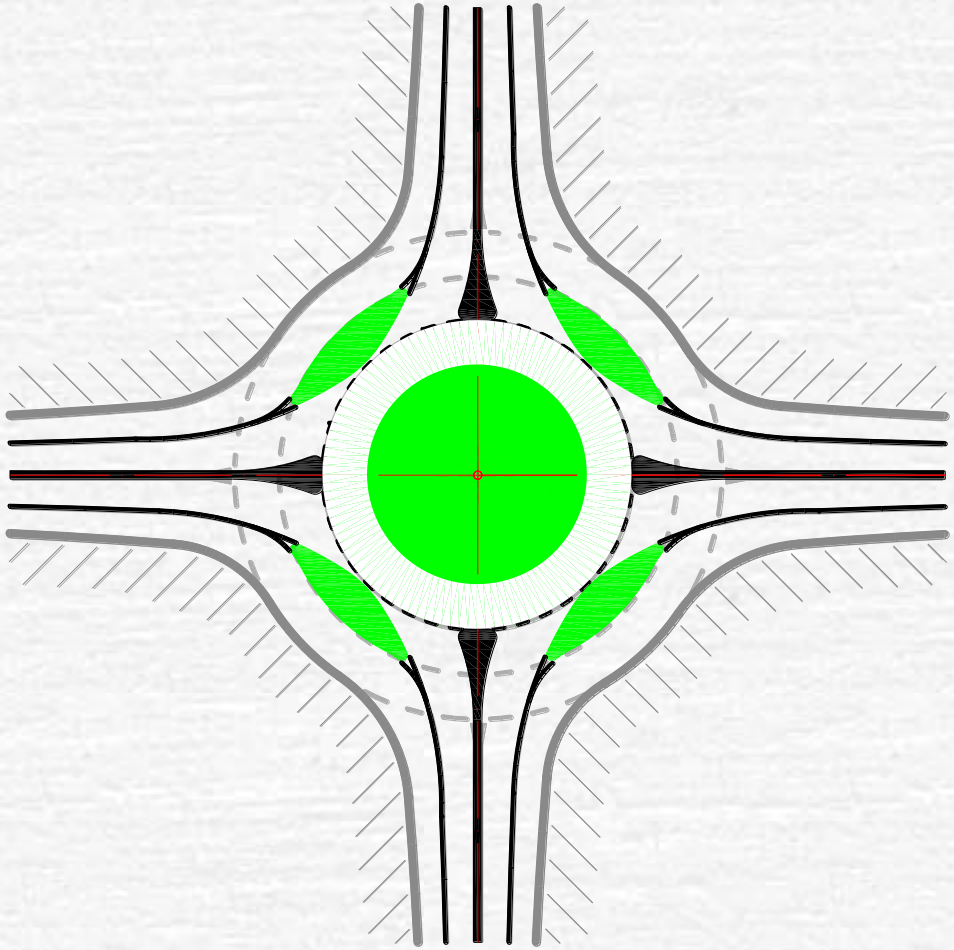
Indicate as novelty is that it is possible to adjust existing ”standard” (less safe) two lane roundabout into (more safe) flower-roundabout without any moving the outer road curbs!

Unlike the turbo roundabout, there is no need to move the outer road curbs!





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



Conditions and locations of appropriate use of the flower-roundabout

The flower-roundabout on locations in the urban area is an appropriate solution! On locations outside the urban areas (one main and one side road, regarding the intensity of the traffic flows), flower-roundabout is just a conditionally appropriate solution!

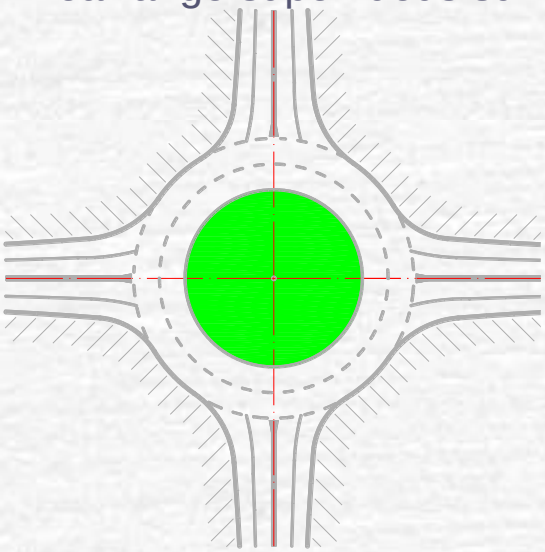
The flower roundabout is an appropriate solution in the case of:

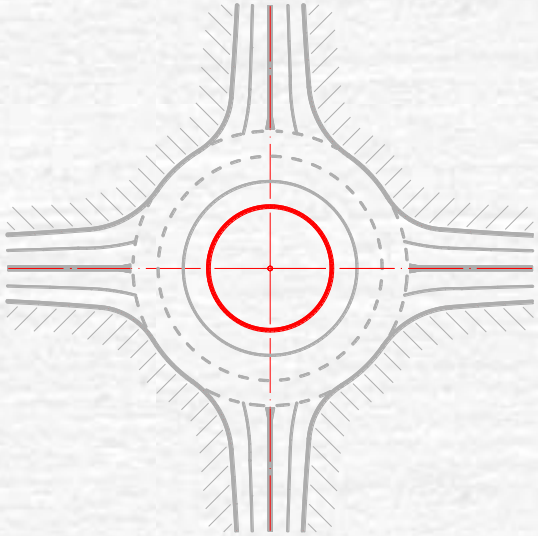
- existing traffic-overloaded one-lane roundabouts, the size of which (outer radius) enables the implementation of an additional circulatory lane inwards (better solution) or there is space for the implementation of another circulatory lane outwards (somewhat less appealing and more expensive solution),
- existing traffic less safe two-lane roundabouts,
- reconstruction of the classic intersection with a situation where on major and minor road traffic flow is near similar, with a lot of right turners,
- a rather large diameter must be given to enable this solution (inside diameter greater than 39 m).

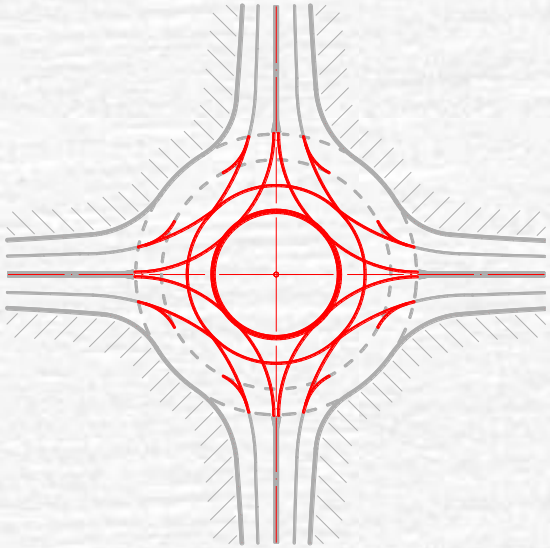
How it works:
http://www.youtube.com/watch?v=TrUQNd9rOAo

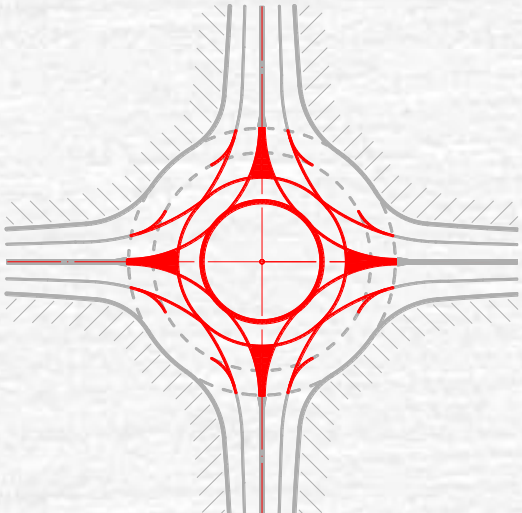
Construction of flower – roundabout

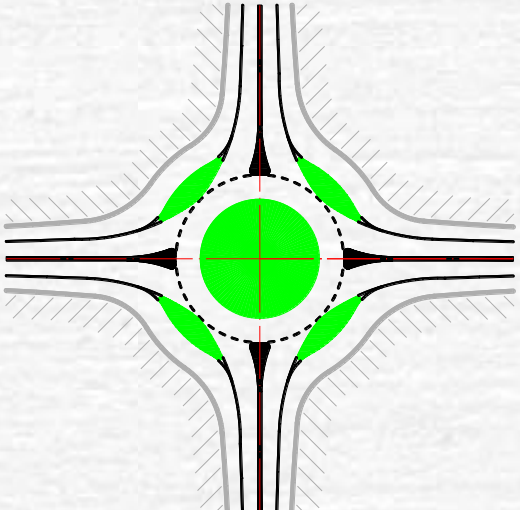
- start situation: existing two-lane roundabout,
- implementation of aditional circulatory traffic lane toward central island,
- extend construction lines of entrances and exits,
- extend separation lines to the outline edge of inner circulatory traffic lane,
- rearrange superfluous surfaces to greenery.









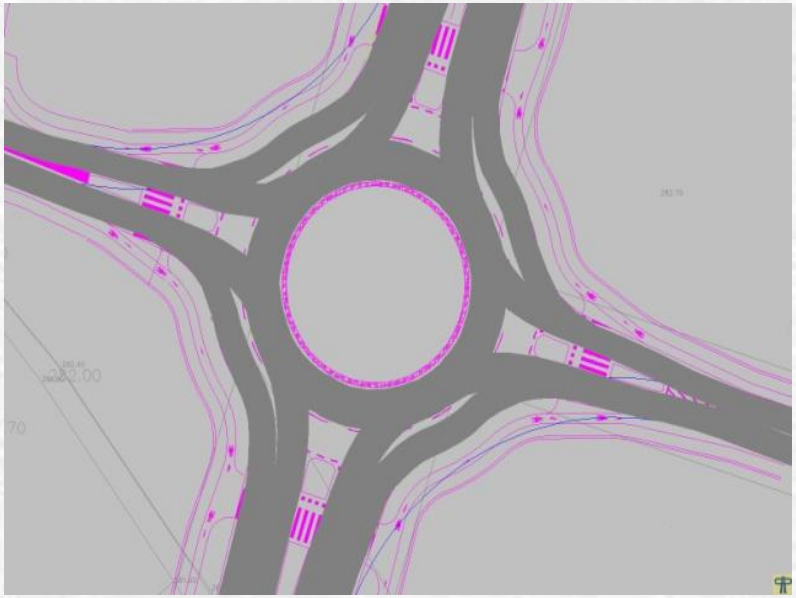


First Capacity Investigations:

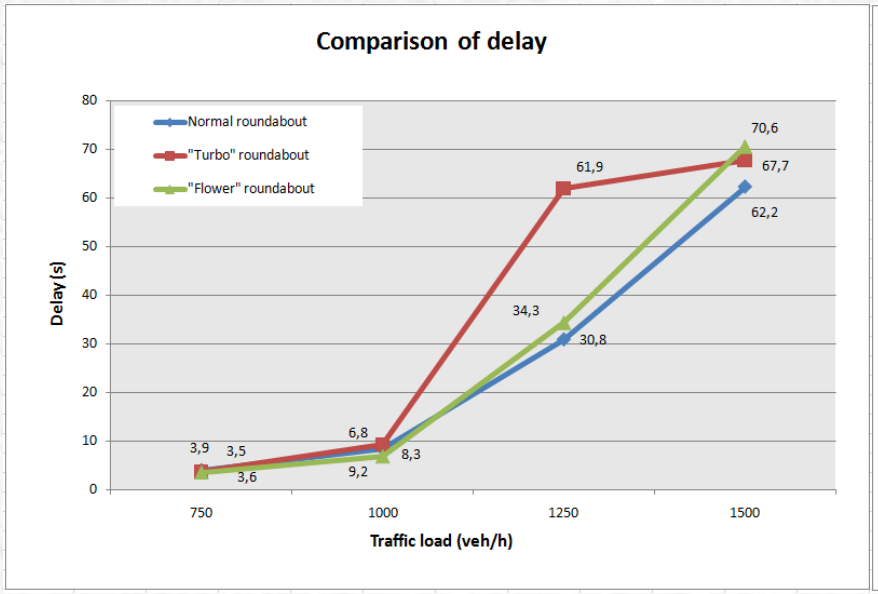
Capacity Comparison Between the Flower-Roundabout, ”Normal” Two-Lane Roundabout and Turbo Roundabout

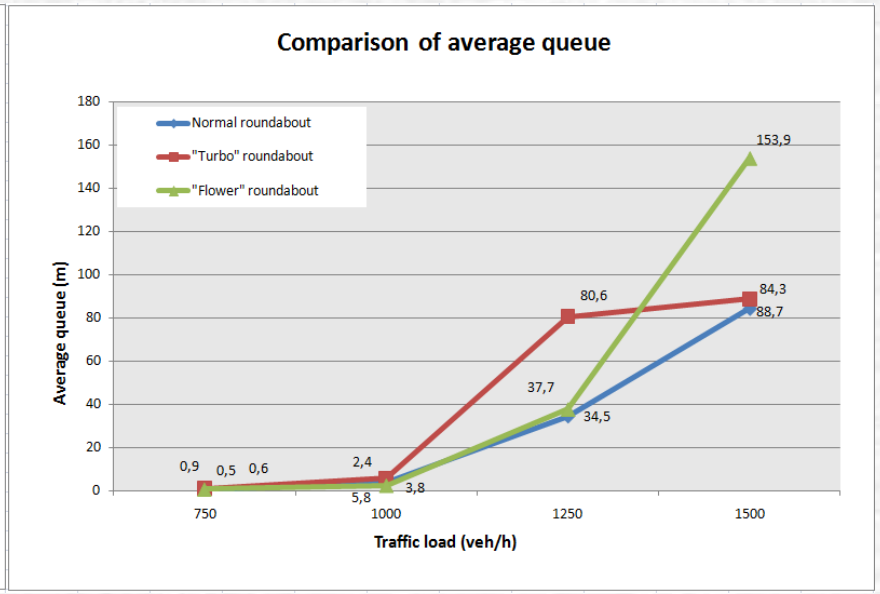
Due to lack of analytical methods for capacity estimation concerning turbo and flower- roundabouts, we have decided to use micro simulation tools: micro-simulation package PTV VISSIM. VISSIM presents a stochastic, discrete, time oriented microscopic simulation model.

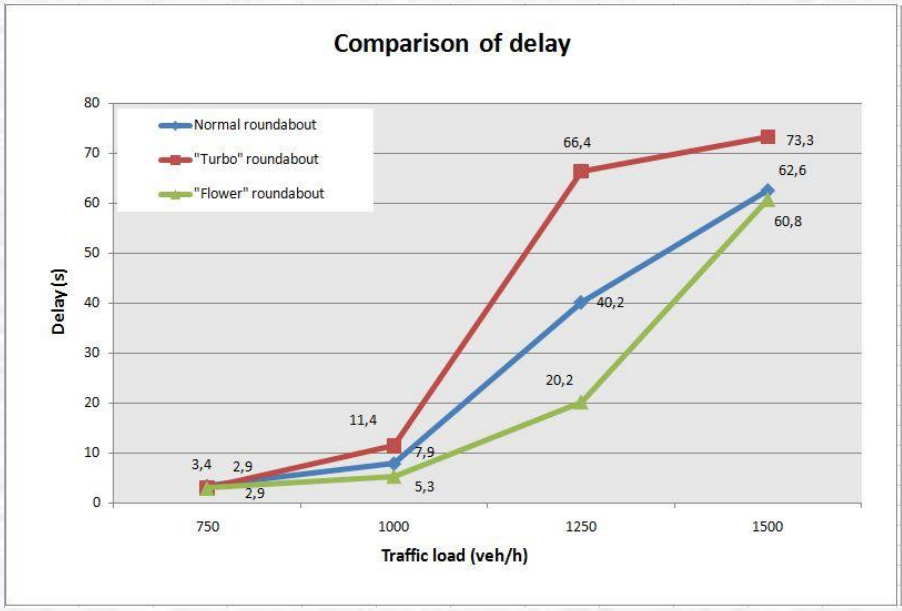
We analysed congestions and the queue lengths for four variants of traffic loads (750, 1000, 1250 and 1500 vehicles in the main traffic direction in the peak hour) and for four variants of right-turners (40%, 60% and 80% right-turners on the main traffic direction).
In all scenarios we add 10% of the main traffic stream on minor streams.

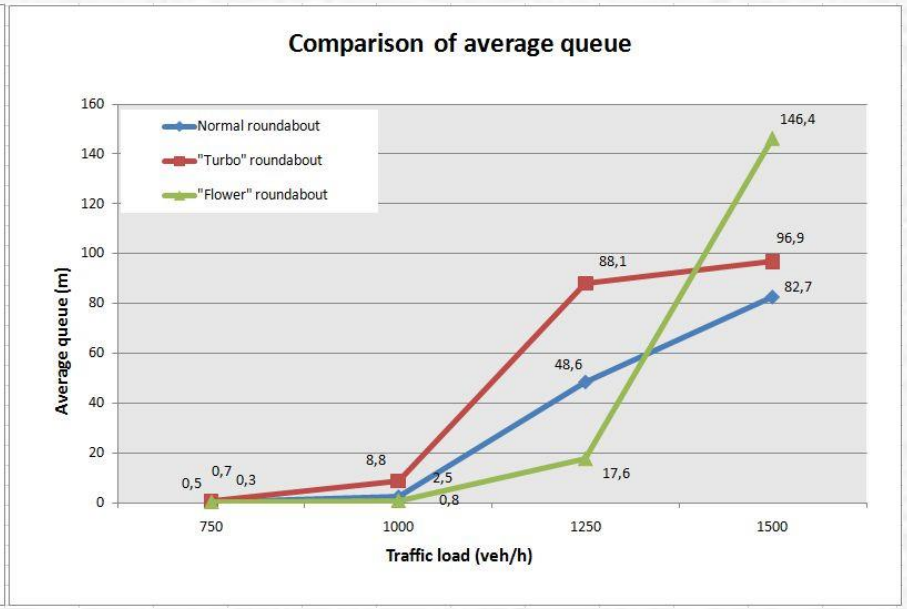


Results of the micro simulation shows that there are no significant differences between the flower-roundabout, normal and turbo roundabout, at a low traffic loads and at a low number of right turners.
Congestions and queue lengths are approximately the same.









At higher traffic loads, the flower-roundabout shows its advantages, when the larger part of the traffic on the main traffic direction, is the direction of right-turners.

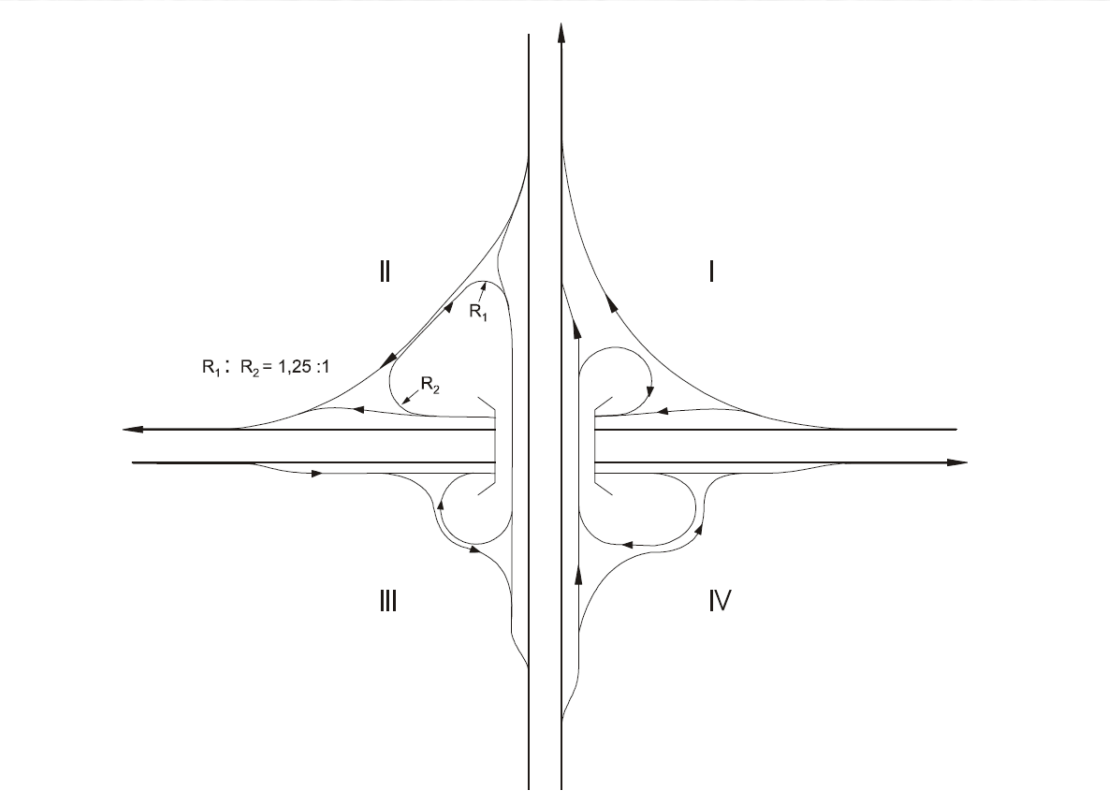
Flower-roundabout burns out when traffic volume on cc exceed capacity of one-lane roundabout.

Capacity comparation:

https://www.youtube.com/watch?v=zFZkHFPogAI

The idea of the ”target-roundabout”:

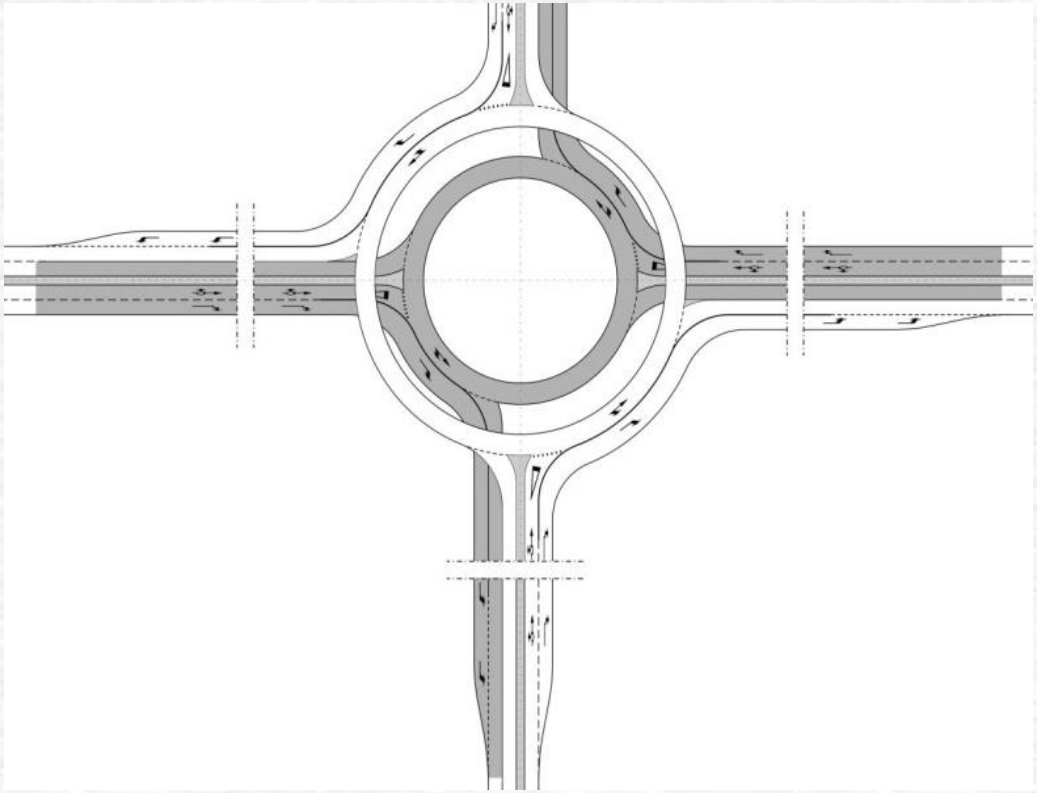
If we need to design an intersection of two four-lane roads (”full intersection” – from all sides to all sides) standard solution is ”cloverleaf” – one of the four combinations



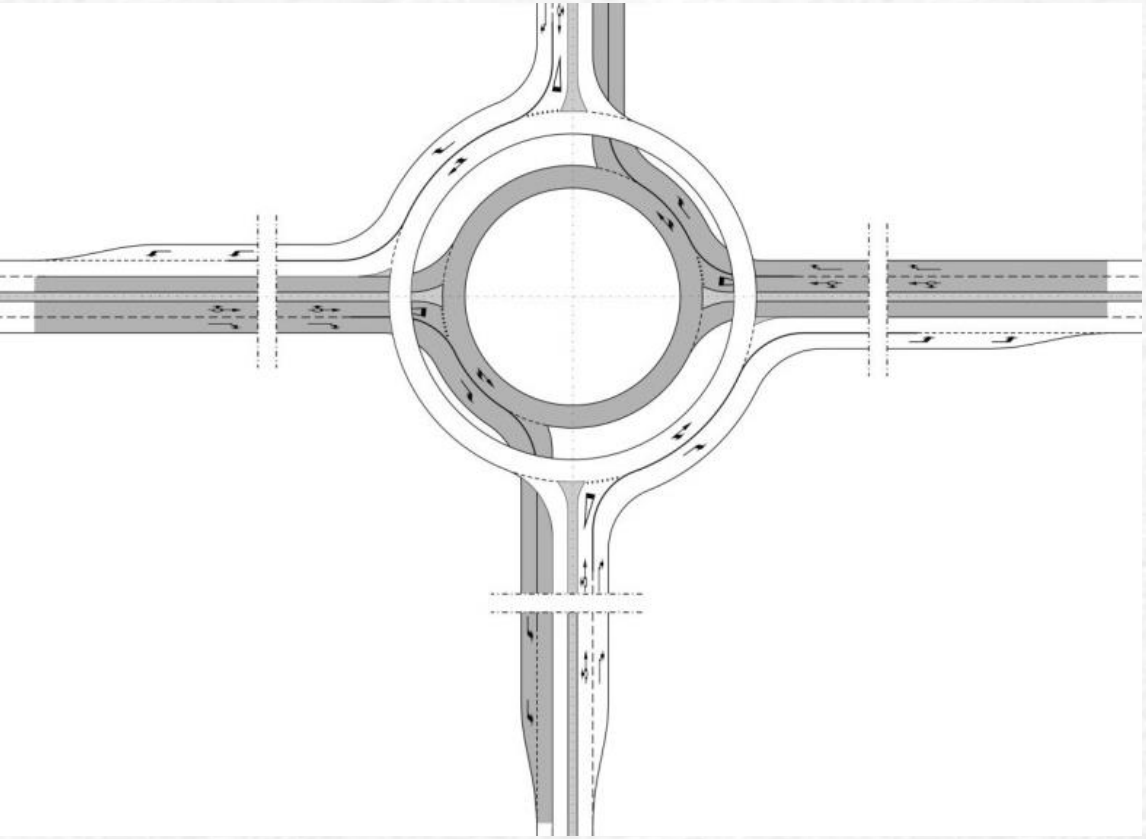
But: For this solution we need a lot of space (a lot of land = a lot of money and a lot of problems with ministry of environment and agriculture)!

... 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)!

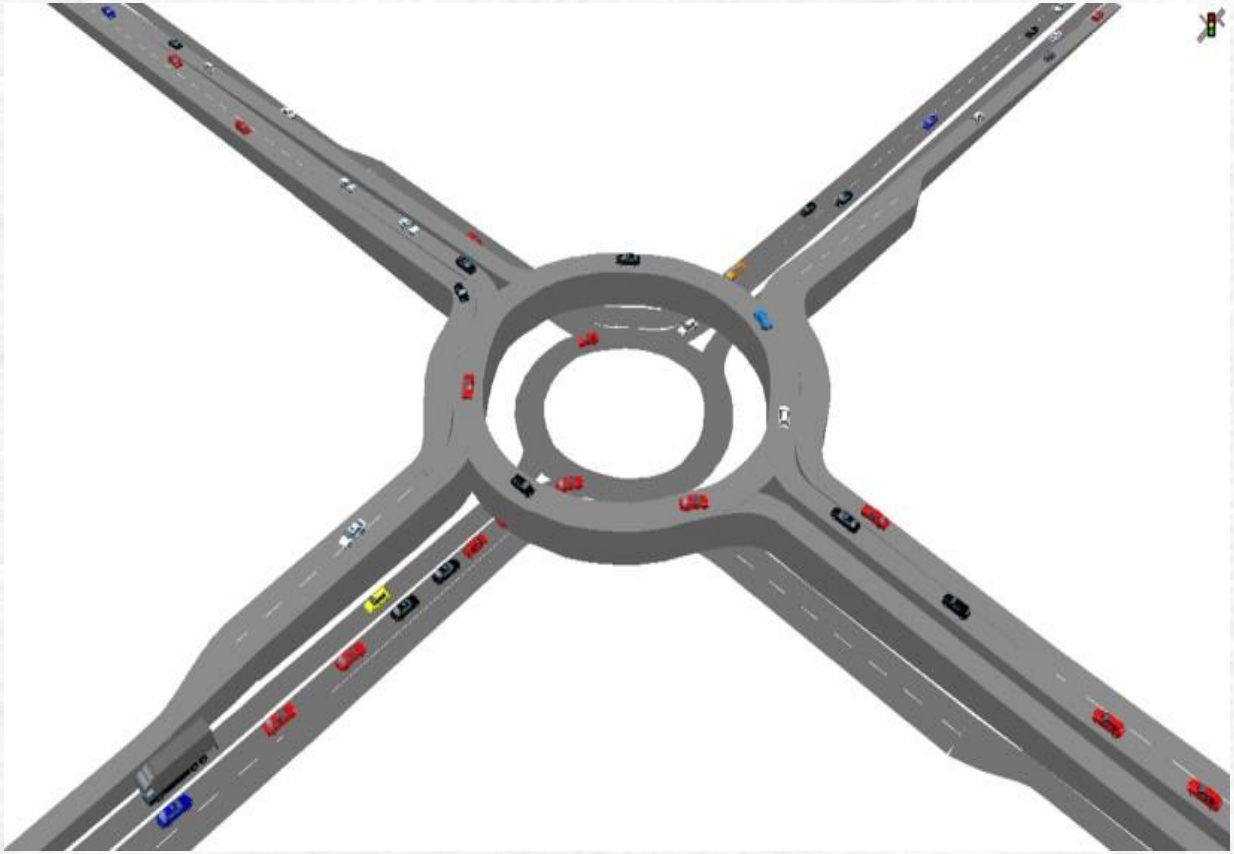


A target roundabout is designed as a two one-lane roundabout with different outer diameters, located on dual levels, and all right-hand turners on both roundabouts have their own, separate right-hand turn bypass lanes.



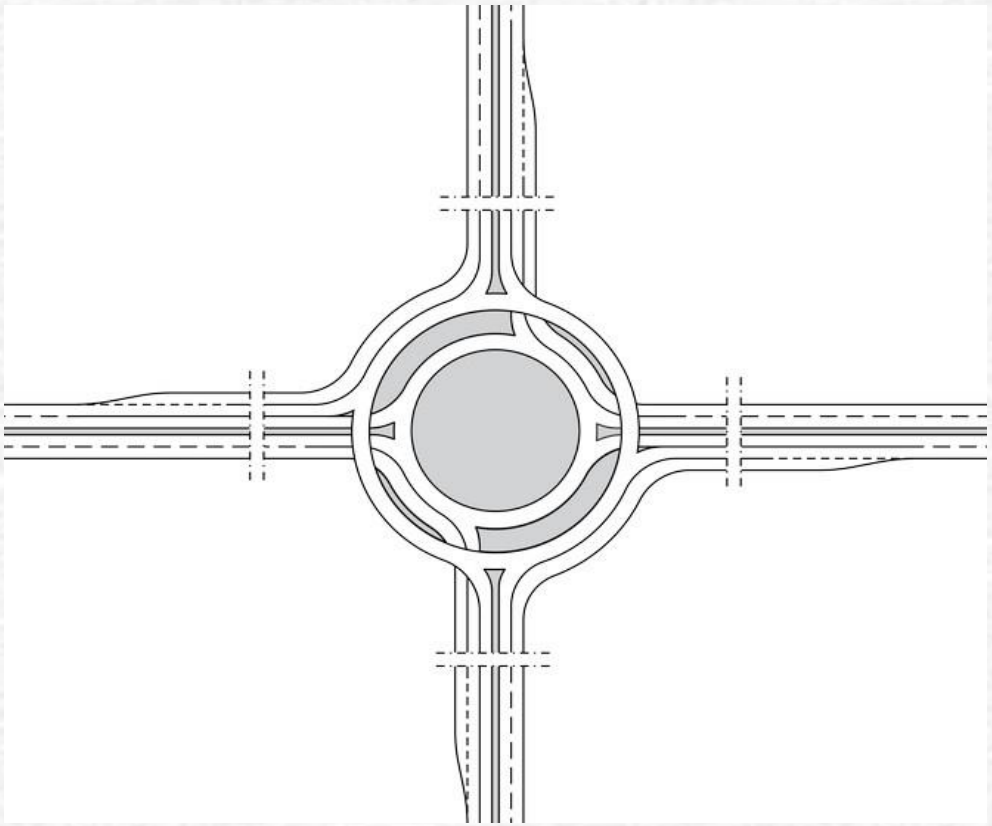
The dual one lane roundabout on two levels allows driving from all directions to all directions.

It also "forgives errors"; if a driver mistakenly stays on the left-hand lane at the entrance it is still possible to turn right at the next exit (different to the turbo-roundabout).



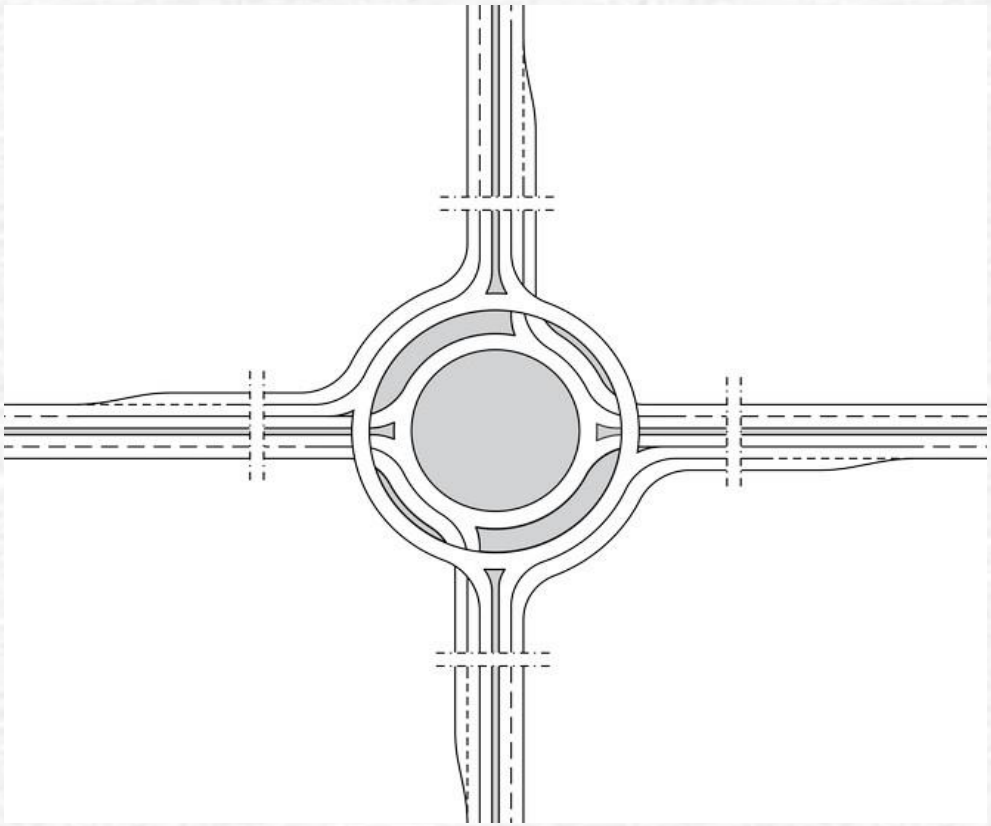
Driving at a target roundabout is the same as on the turbo-roundabout (the same philosophy of signposting and lane-marking).

How it works:
http://www.youtube.com/watch?v=FP9AuAtdXDw&feature=youtu.be



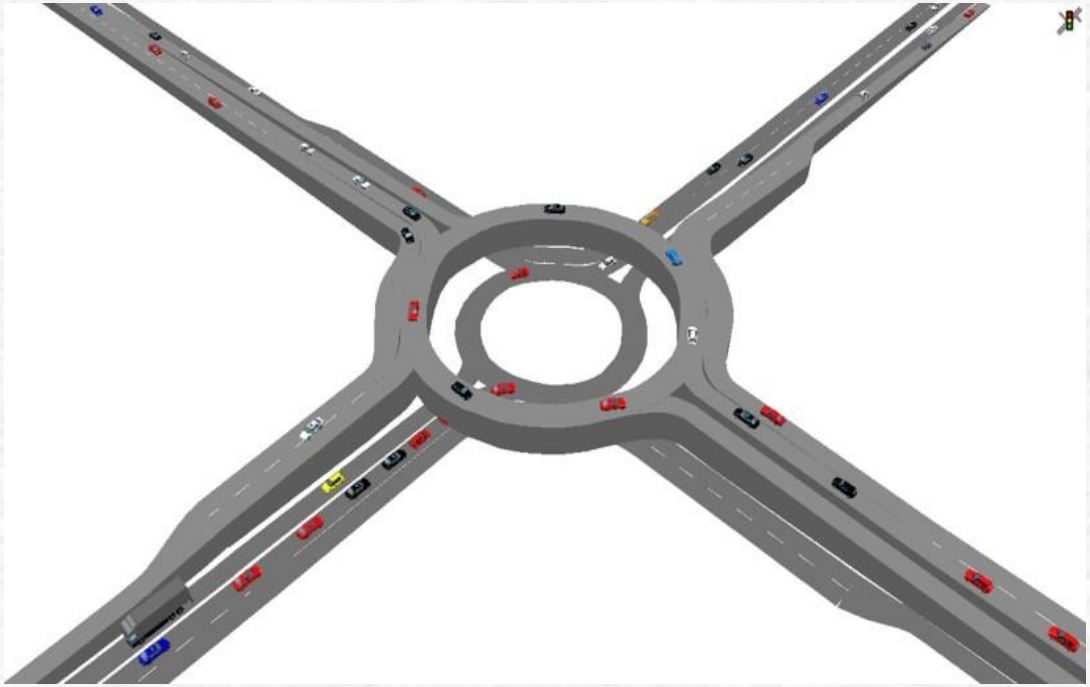
One of the basic characteristics of the target roundabout is the same as at the turbo and flower roundabouts - physically separated traffic lanes within a circulatory carriageway; bypasses and one-lane circulatory roadway sections.

All right-hand turners have their own separated traffic lanes; consequently the inner circulatory roadway is used only by vehicles that drive through a roundabout (180°), turn for three quarters of a circle (270°), or turn semicircle (360°).



A target roundabout is especially useful within suburban areas, with plenty of space, where two-level interchanges (standard diamond, diverging diamond, cloverleaf interchange…) are all possible solutions.

However, this solution is acceptable also in urban areas due to small size. D=75 m (comparation with cloverleaf!)

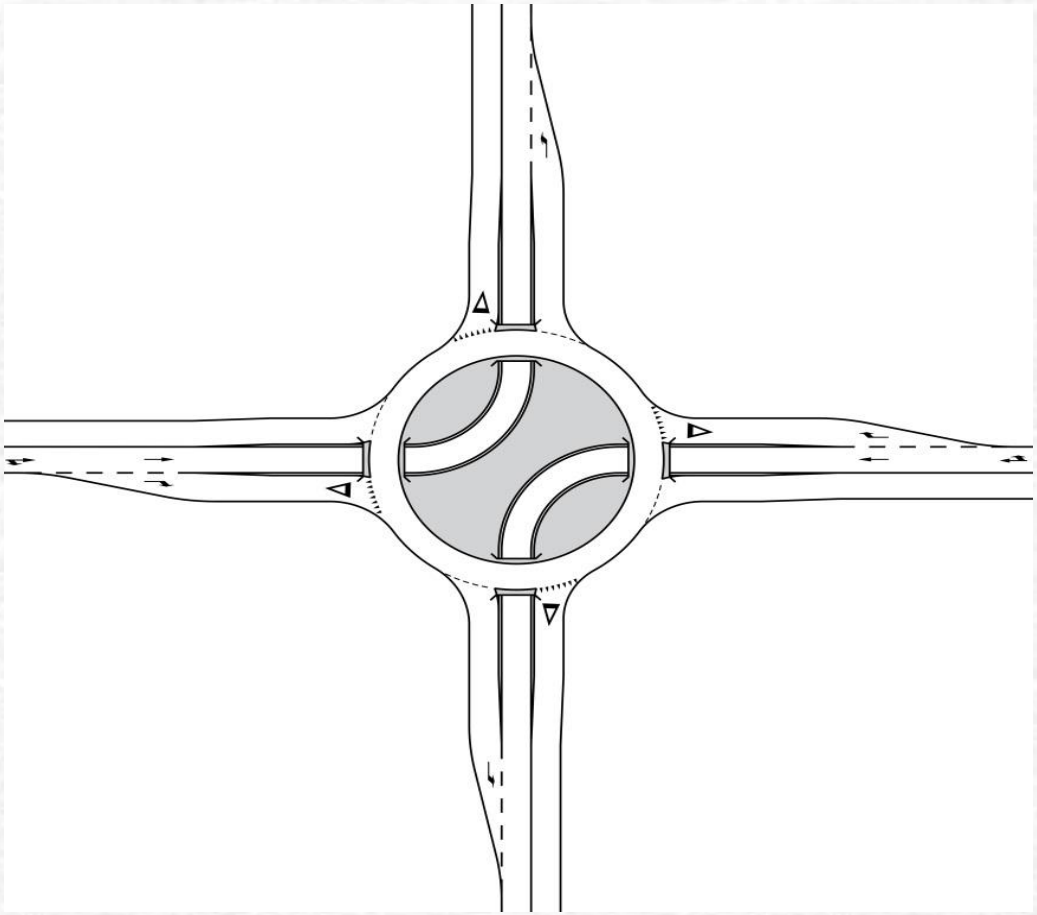


In accordance with the results of the micro simulation, carried out using VISSIM, we can summarize that the target roundabout (with diameter of the larger roundabout D = 75 m) could serve the interchange with 50,000 AADT with a good level of service and up to 60,000 AADT with a level of service F, in accordance with HCM 2010 criteria.

Compared with e.g. the cloverleaf interchange, this would be a big disadvantage due to capacity criteria, but in the case of urban space limitation, the possible target roundabout would need to be taken into consideration and analyzed using forecasted traffic.

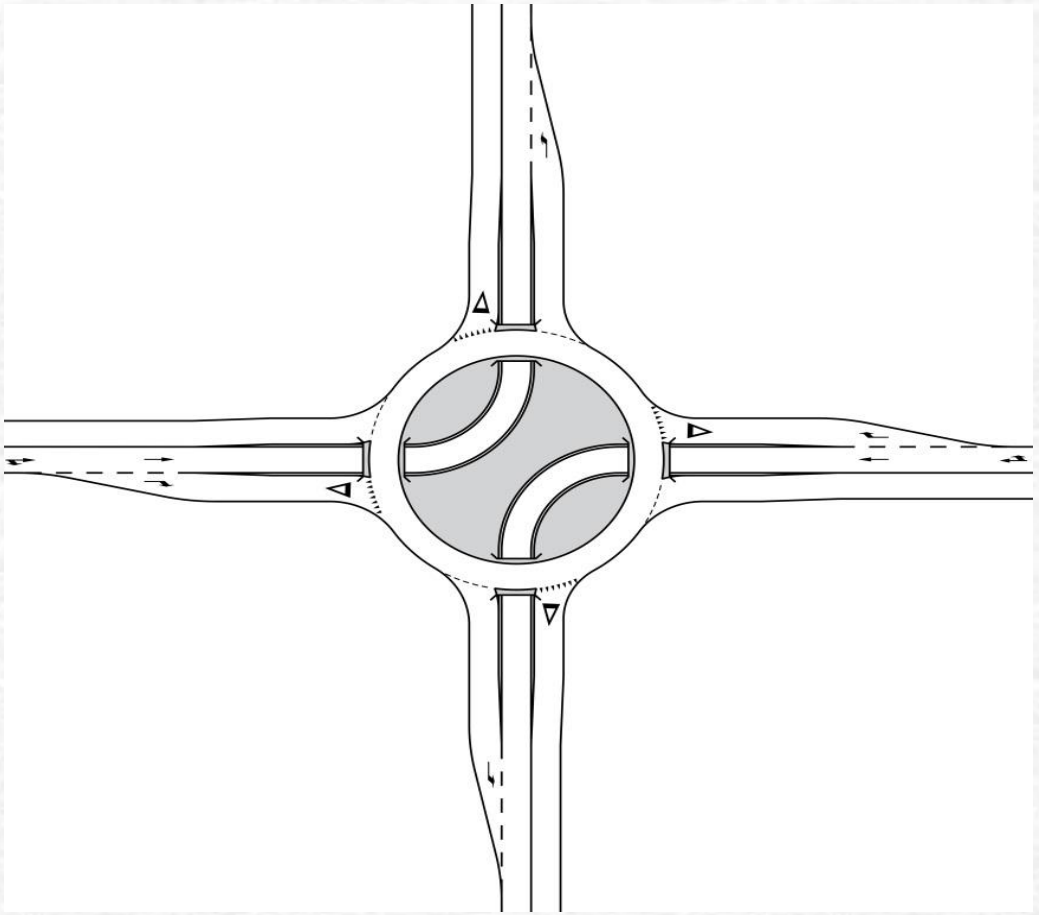
The roundabout with segregated left-hand turning bypasses (slip-lanes) on major roads – in short the "four flyover roundabout" is at the moment also at the development phase - and also patented.

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.

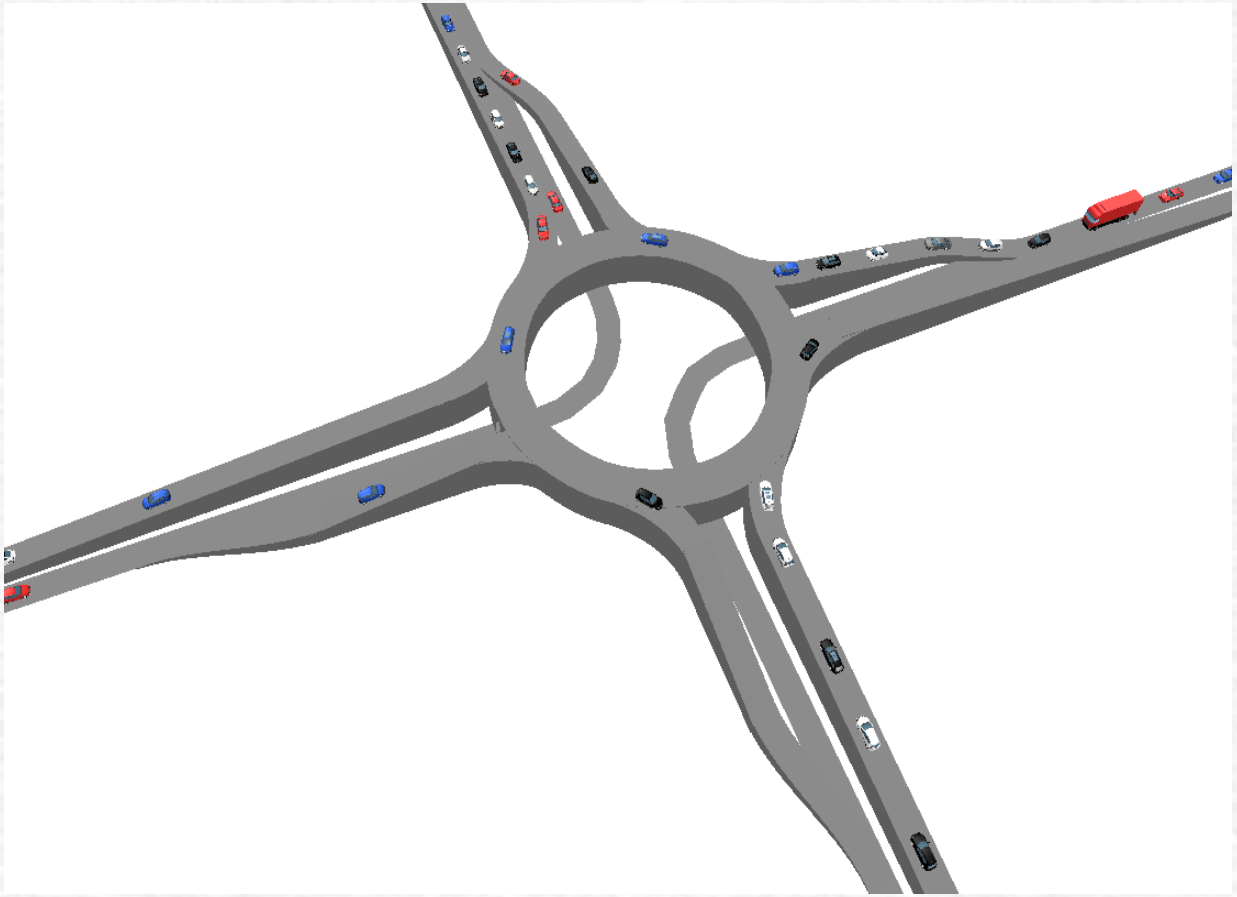


By physically separating left-hand turning traffic flow on major roads, we obtain a one-lane roundabout by physically separating the left-hand turning traffic flow on major roads, with no crossing and also no weaving conflict spots.

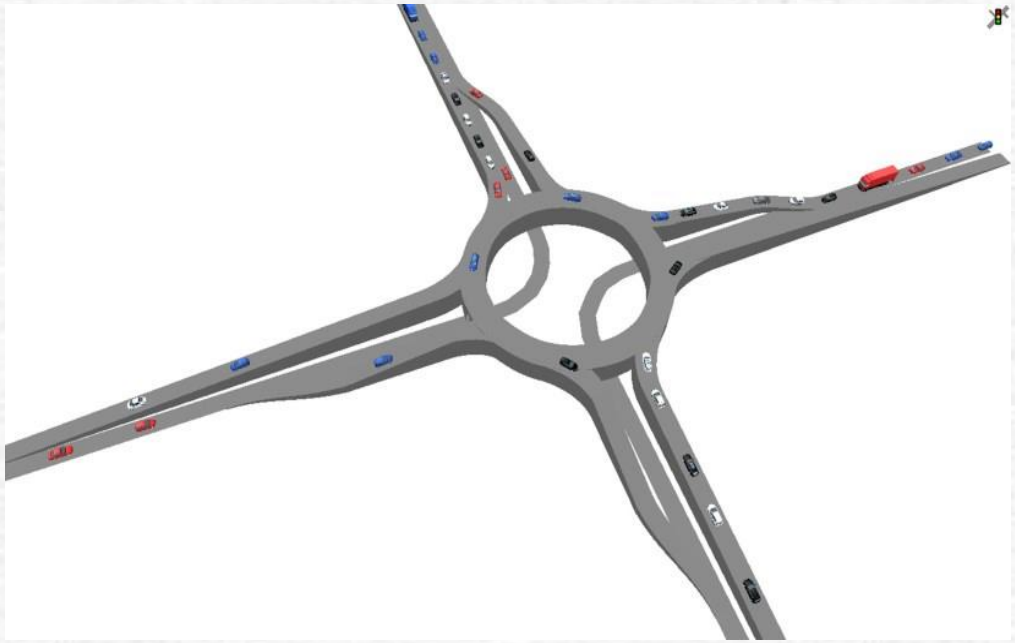
Any possible weaving conflict spots when transferring from the circulatory carriageway onto the road section are in front of a roundabout (as in the case of the turbo, flower, and target roundabouts), being a safer solution from the traffic-safety point of view.



How it works:
https://www.youtube.com/watch?v=XoDF6nqmzdI



A four flyover roundabout is especially useful in urban areas, where we do not usually have plenty of space, and standard two-level interchanges (standard diamond, diverging diamond, cloverleaf interchange…) are usually not feasible solutions.



Following the results of micro simulation, it could be summarized that four flyover roundabout (with diameter D = 90 m) could serve an interchange with about 45,000 AADT.

There are few variations of this type of solution. It could be constructed as a standard one-lane roundabout or with segregated right-hand turning slip-lanes.

A **roundabout with segregated left-hand turning slip-lanes on major roads and right-hand turning slip-lanes on minor roads**, in short the **"roundabout with left and right slip-lanes“**, is a variation of the four flyover roundabout, and is also at this moment at the development phase.

A roundabout with left and right slip-lanes is also a hybrid like a four flyover roundabout, combining a one-lane roundabout, right-hand turning slip-lanes, and left-hand turning slip-lanes located on another, lower level.