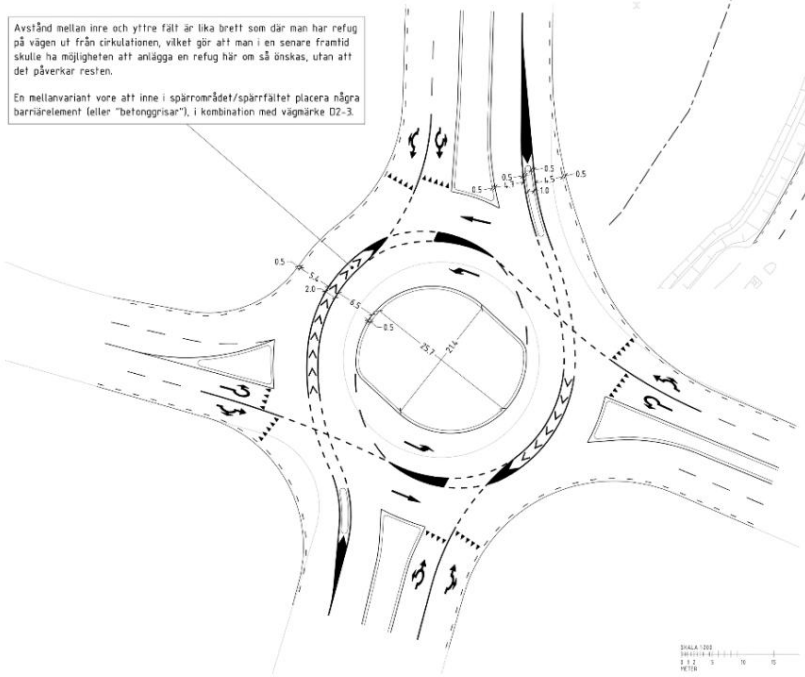
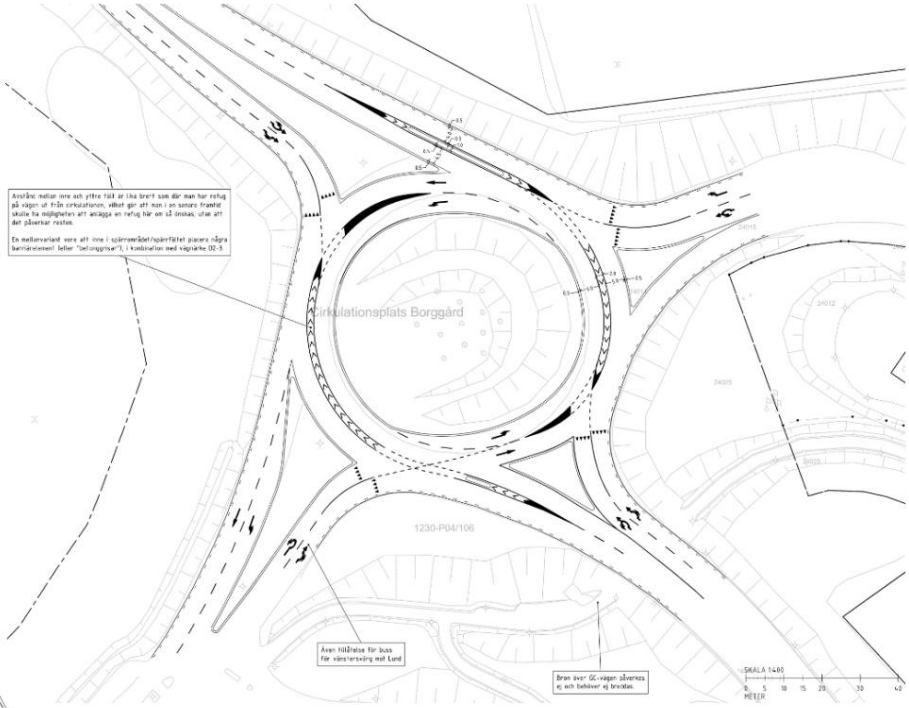
PM

Hasselcirkeln – New design of roundabouts

Example less circulation





Example large circulation

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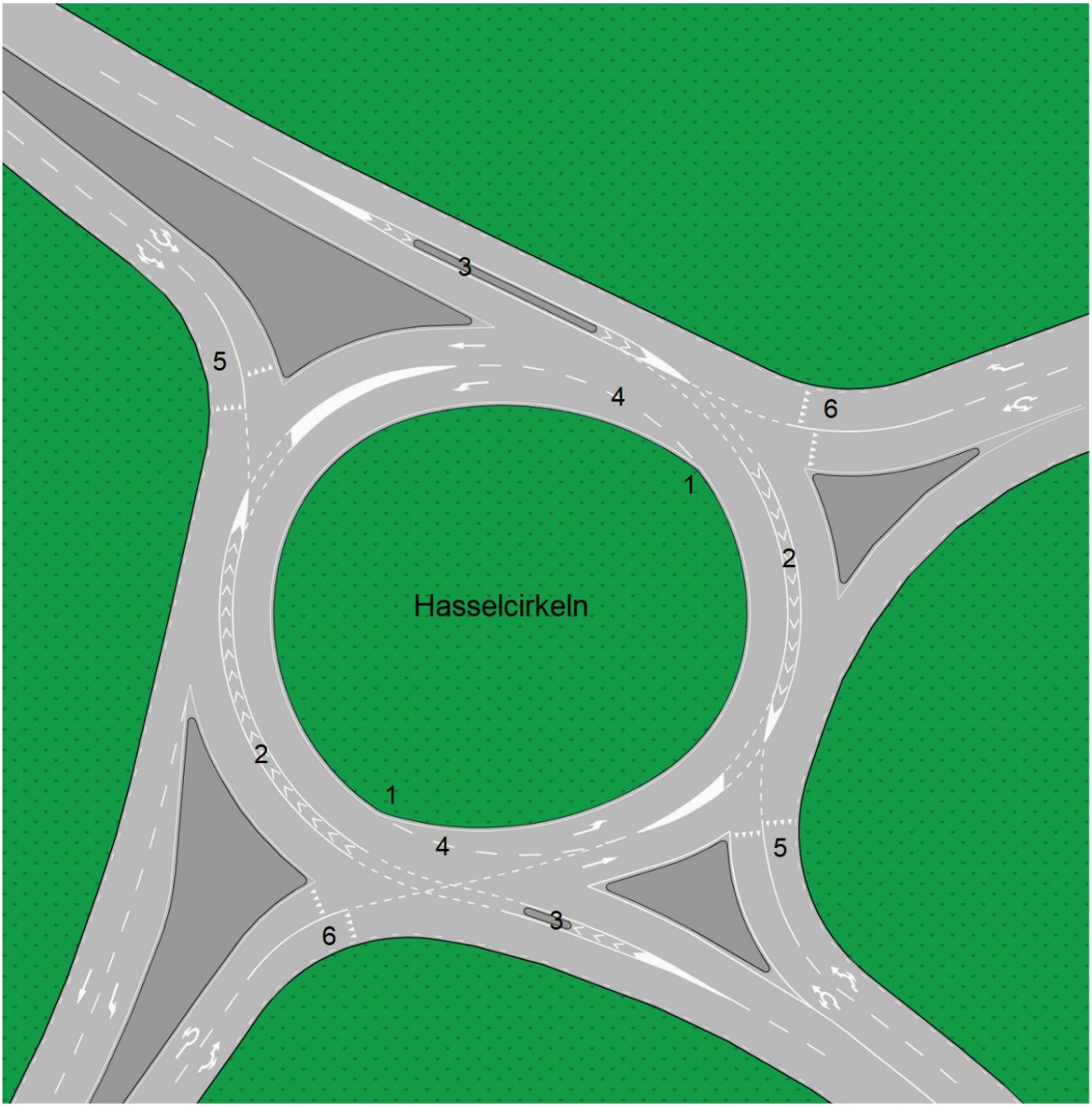
1. Summary

A new design of multi-lane roundabouts has been developed, called the Hassel circle. The new design aims to reduce the number of conflict points compared to today's multi-lane roundabouts. Furthermore, the Hassel circle aims to increase the accessibility of roundabouts, as today's multi-lane roundabouts mean that vehicles in certain relationships give way to each other "unnecessarily". With the Hassel circle, vehicles traveling in the right lane on their way into the circulation in some cases in practice do not need to give way to vehicles in the inner circulation lane. A computer simulation (VISSIM) with general flows indicates that the number of vehicles that can pass the circulation during a certain time increases by **approximately 22%.** Studies of the closely related Turbo-roundabouts in the Netherlands have shown a reduction in the number of incidents by **around 72%.** In both cases in comparison with corresponding circulation space with today's design.

In general, roundabouts are safe types of intersection, largely due to the fact that all vehicles travel at a relatively low speed. On the other hand, the occurrence of minor accidents (incidents) is relatively common and, not least, "near-accidents" are common, where a vehicle, for example, needs to brake hard for another vehicle. For this reason, today's multi-lane roundabouts can in many cases be perceived as messy and unclear for the traffic. In roundabouts with double circulating lanes, a driver who is in the inner circulating lane has the obligation to check whether it is free in the outer circulating lane when he is to drive out of the roundabout. If there is a vehicle in the outer circulating field at the same time, a conflict may arise. In roundabouts with double circulating lanes, according to practice, you should use the inner circulating lane when, for example, turning left. However, it is fully permitted to travel all the way in the outer circulating field, which increases the risk of conflicts.

With the Hassel circle, it is not permitted to change lanes between the inner and outer circulating lane. Nor does the driver need to change from inner to outer field when exiting the circulation. Instead, the driver can continue to follow his lane all the way from entrance to exit through the roundabout. Unlike, for example, a turbine-painted roundabout, there is also a sudden/transverse angle change where the new inner lane begins, which makes it clear to the road user traveling in the inner circulating lane that they should continue in their lane, instead of continuing to travel along the inner edge (closest to the rim surface). In a turbine-painted roundabout there is instead the risk that the driver does not understand whether he should follow the turbine-painted line or continue traveling along the inner edge. Hasselcirceln is similar to the Dutch concept of Turbo-roundabouts, but enables U-turns (which Turbo-roundabouts usually do not) and is generally more similar to today's roundabouts than a Turbo-roundabout does in its design. Hasselcirkeln is developed by Sebastian Hasselblom, traffic analyst/civil engineer at the technology consultancy WSP.

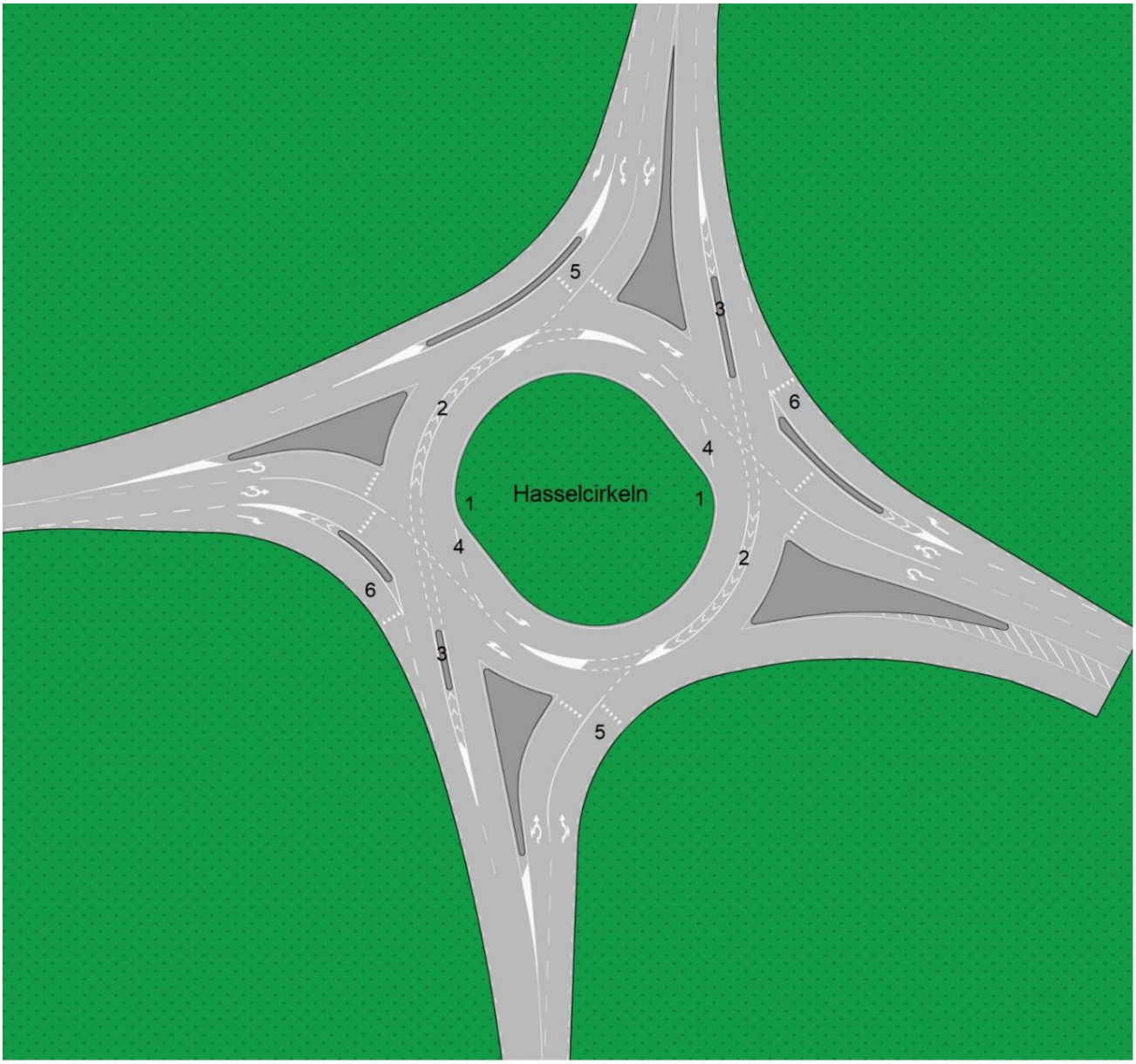
WSP's drone filming, example of conflict in today's design of multi-lane circulation site. The black car must panic brake to a complete stop for the red car.



(1) Plötslig/snäv vinkeländring där det nya inre fältet börjar (skapar tydlighet hos förarna att de ska fortsätta i sitt körfält istället för att följa innerkanten)
(2) Brett spärrfält/spärrområde mellan inre och yttre körfält inne i cirkulationen (skapar tydlighet hos trafikanten, samtidigt som snöröjning kan hanteras som idag, kommer heller inte att slitas som körfältslinjer ofta gör i cirkulationer eftersom inga fordon ska färdas här, inte heller långa fordon behöver nyttja denna yta)
(3) Refug mellan körfälten på avfarten (gör det än tydligare för trafikanten som färdas i det inre cirkulerande fältet att de ska färdas till vänster om refugen vid utfart, dvs. att de inte ska byta till det högra körfältet)
(4) Tillåtelse att byta körfält på sträckan närmast efter den plats där det nya inre fältet har börjat, vilket möjliggör U-svängar
(5) Trafik som färdas i höger fält behöver i praktiken inte väja för trafik i det inre cirkulerande körfältet, vilket ökar framkomligheten (väjningsplikten gäller mot all trafik i cirkulationen där föraren bedömer vilka hen behöver väja för, utifrån att varken fara eller hinder ska uppstå)
(6) Samma som (5), fast i detta fall enbart för högersvängande trafik

Example 1 of the design of a Hassel circle, with explanations for typical characteristics.

In this example, there are double through lanes straight ahead in both directions between northwest and southeast. When approaching the roundabout from the south-west, straight ahead and right in the right-hand lane are signposted, while from the east only right turns are allowed in the right-hand lane.



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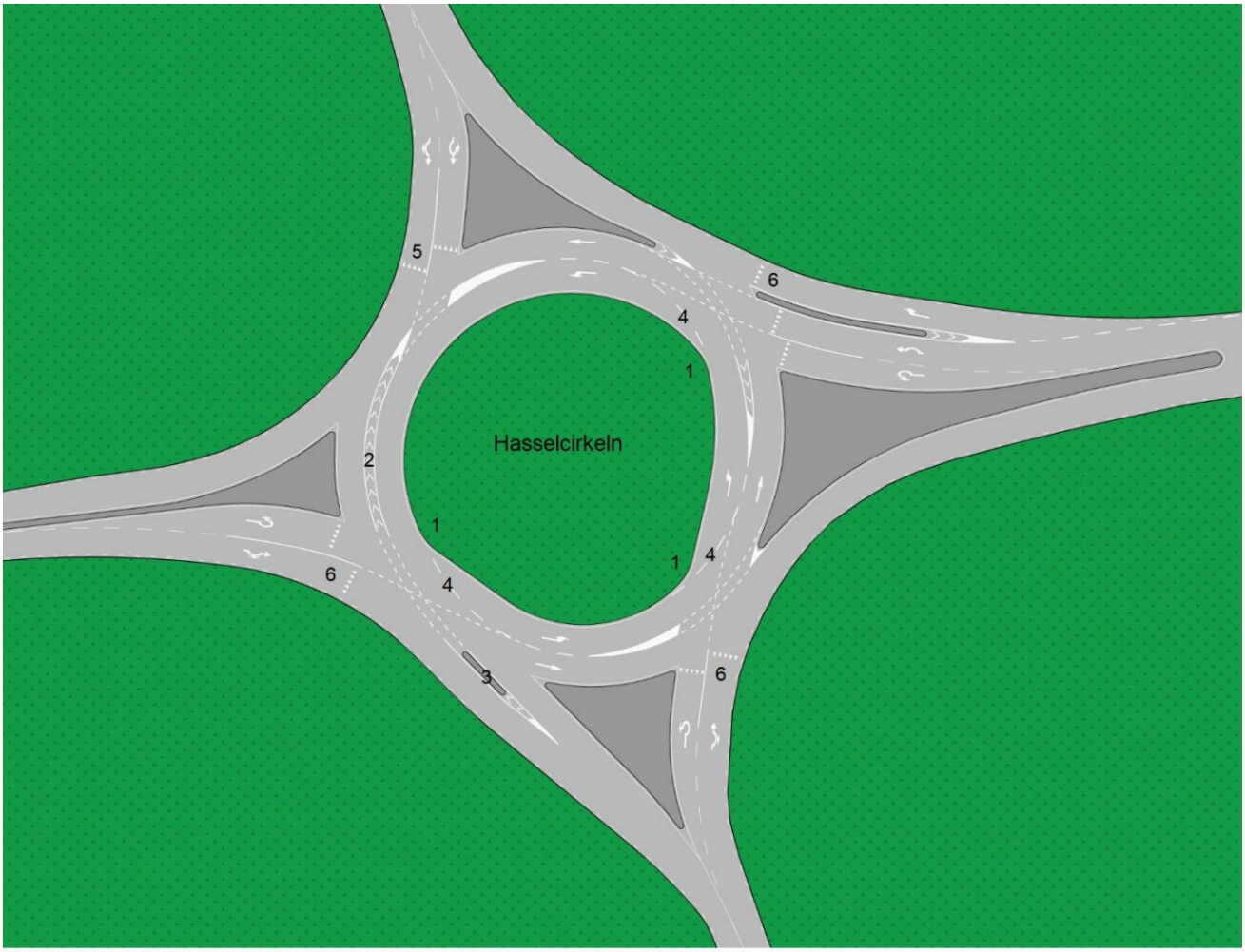
Example 2 of the design of a Hassel circle, with explanations for typical characteristics.

In this example, there are double through lanes in both directions between south and north. When approaching the roundabout both from the east and the west, both lanes can be used for left turns, and that there is a separate lane for right turns. Even from the north there is a separate field for right turns, in this case in the form of a free right.



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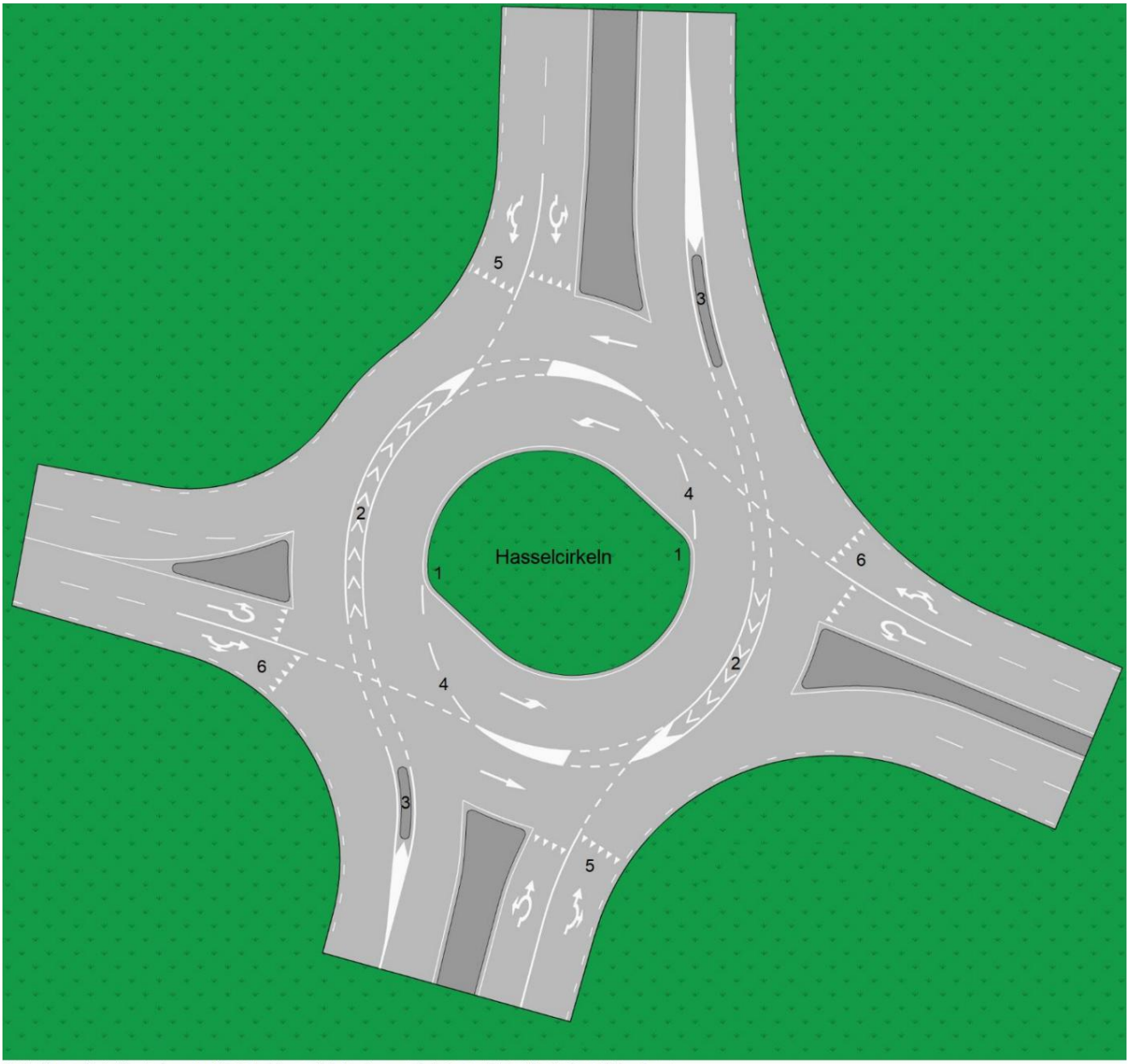
(6) Samma som (5), fast i detta fall enbart för högersvängande trafik

Example 3 of the design of a Hassel circle, with explanations for typical characteristics.

In this example, there are only double lanes straight ahead from one of the entrances to the circulation instead of two, in this case from the north. This means that this circulation is designed a little differently, among other things in the form that there are three sudden/tight angle changes where the new inner lane grows out instead of two as in the others.

If you have a roundabout with only exits with one (1) lane, the Hassel circle can still be useful. Then the entire circulation would be like the eastern half of the sketch above, with thus a total of four sudden angle changes (no. 1 on the sketch above) and no places at all where there is a barrier/restriction area between the lanes on long stretches (no. 2 on the sketch above). However, you get the most benefit from the Hassel circle if you have two lanes facing one or two of the exits. In many cases, it can also be created relatively easily, as you can let the lanes merge with each other after about 60 – 80 meters after leaving the circulation (road sign E15, interweaving). See, for example, the sketch above regarding how it is drawn on the exit to the south (in this specific case, there is a bridge in the farthest south which limits how far you can have two lanes).



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Example 4 of the design of a Hassel circle, with explanations for typical characteristics.

In this example, the circulation is smaller, with an inner diameter of about 30 meters with today's design (inner radius about 15 meters), but in connection with the conversion to the Hassel circle, some area towards the center would be used. This is in order to make it possible even for long vehicle crews to stay within their lane (even during U-turns).

In this example, there are double through lanes straight ahead in both directions between north and south. When approaching the roundabout from the west and east, signs are straight ahead and right in the right lane and left turn in the left. This type of lane division and size of circulation space is very common.

2. Background

A new design of multi-lane roundabouts has been developed by Sebastian Hassel-blom, traffic analyst/civil engineer at WSP. In the early discussions at WSP, several competences were also connected, including road safety experts. WSP as a company judged that the concept tank should be named, where the name Hasselcirkeln was chosen. During the fall of 2021, WSP presented the concept idea on two webinars, after which the Swedish Transport Administration, among others, showed interest in the solution.

During the beginning of 2022, further discussions have been held between WSP and various competences within the Swedish Transport Administration, where various types of issues regarding design, traffic safety, law, etc. have been raised. This has resulted in a more precise idea of a possible design, which has also been drawn up in CAD for a number of specific possible locations.

This PM describes the entire trip, i.e. from the concept idea to the more precise idea about the design. Furthermore, the shortcomings that are judged to exist with today's multi-lane roundabouts are described.

3. Purpose

The Hassel circle aims to reduce the number of conflict points compared to today's multi-lane roundabouts. Furthermore, the Hassel circle aims to increase the accessibility of circulation places, as today's multi-lane circulations mean that vehicles in certain relationships give way to each other "unnecessarily". Further explanation of this is given in later chapters.

4. Flaws with today's multi-lane roundabouts

This chapter describes shortcomings of today's multi-lane roundabouts. This chapter summarizes the information highlighted in the web presentation produced by WSP which describes this very thing and which is available on YouTube, search for "Hasselcirkeln" (direct link: https://youtu.be/AjYwDbaL094). Thanks to the fact that the web presentation also contains several film clips from real situations, the description becomes clearer in the video, compared to this chapter.

4.1. What does the traffic school and general practice say about how to drive?

If there are instructions on the way into a roundabout about which lane to use for a certain journey, you should also follow this. If there is no such instruction, practice says that you should drive as below.

Practice how to drive in multi-lane roundabouts, unless it is specifically stated which lane to use for a particular journey.

If you are going straight ahead and there are double lanes both on the way in and out of the circulation, practice says that you can also use the left lane on the way in, the inner lane inside the circulation and then continue in the left lane on the way out of the circulation. If you have to turn left in the roundabout and there are double lanes on the way out of the roundabout, general practice says that you can wait to change from the inner lane of the roundabout to the first level with the exit and that here you continue directly into the left lane on its way out of circulation.

In connection with changing lanes from the inner to the outer, you are obliged to check that it is free in the outer lane. This regardless of where you change lanes, i.e. if you change a bit before the exit (according to the red circle in the picture above) or if you change exactly at the height of the exit.

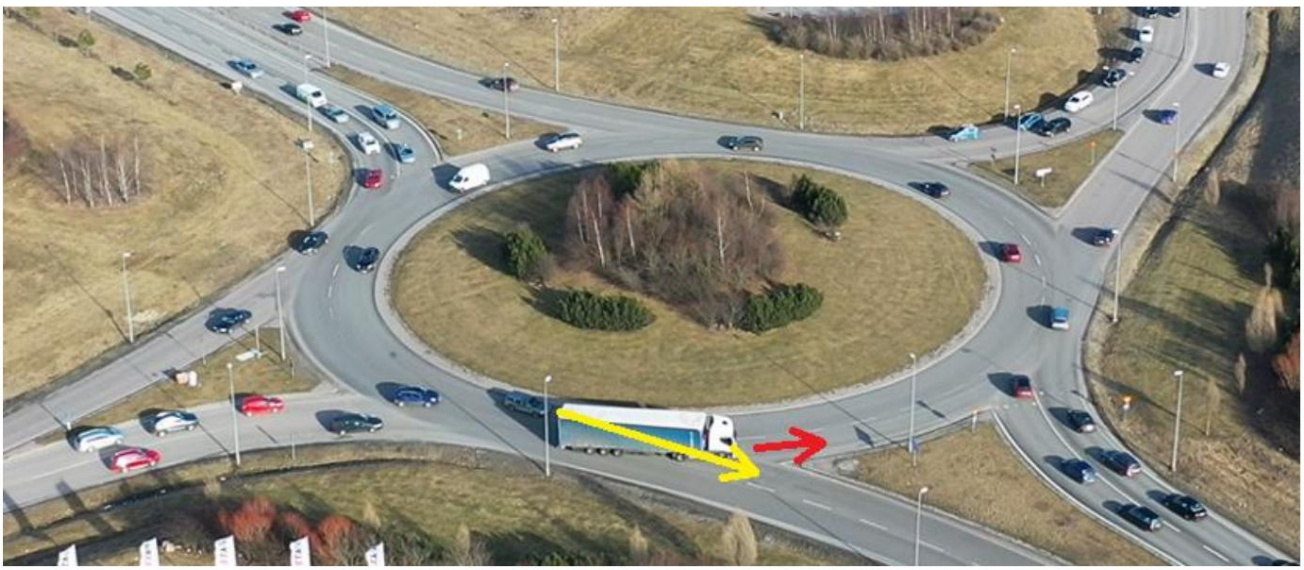
4.2. How is it allowed to drive?

Since the lanes in the circulation are seen as a "road", it is permitted to continue following both inner and outer lanes as far as you want in the circulation. In cases where two driving lanes are painted all the way around, this means, among other things, that it is fully permitted to make a left turn by using only the outer lane. Even U-turns are permitted, without using the inner lane.

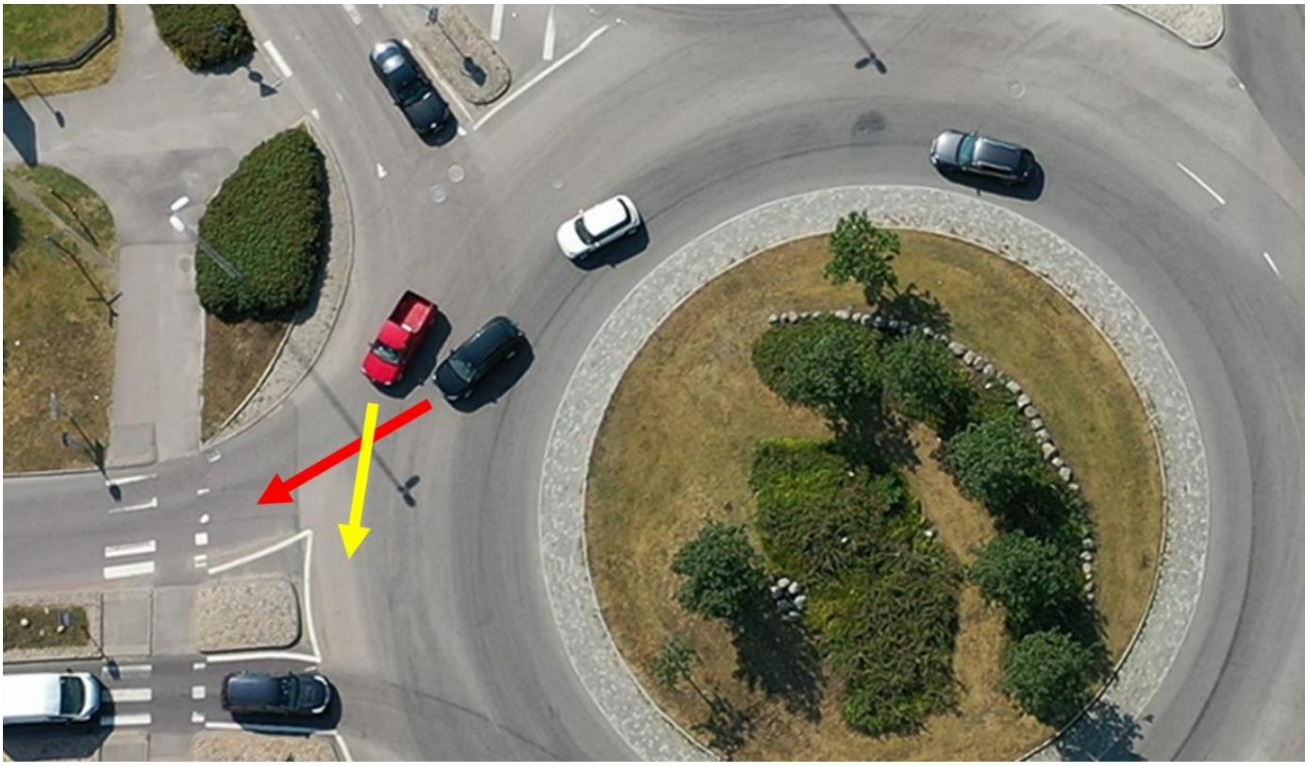
Since it is the road user who changes lanes who is considered to be at fault if an incident occurs, this means that it is rather the road user who follows practice who is considered to have made a mistake than the motorist who drives against practice. However, it is not only in connection with a driver driving against practice that this type of incident risks occurring. It could just as well be that a driver who has driven into the circulation via another entrance, uses the outer lane, and catches up with a vehicle traveling in the inner lane so that they end up parallel. When the vehicle in the inner lane then has to change to the outer lane, the vehicle in the outer lane is "in the way". The greatest risk is considered to be in such situations where a driver chooses to change from the inner to the outer lane right in front of the exit, because the driver then cannot choose to wait a little with the lane change (without missing the exit).

4.3. Real observations

The majority of drone footage conducted by WSP on typical days has been specially studied to find "near misses". For all observed circulations, it has always been possible to find a handful of situations of this kind only during approximately 1 – 2 hours of filming, which indicates that the problem should be considered relatively large, even though circulations are generally safe crossing points thanks to the fact that all vehicles maintain relatively low speeds. However, it is worth pointing out that even minor incidents and "near-accidents" are, of course, still to be regarded as unimportant, since this type of situation can be experienced as psychologically stressful for the individual, and that many people may feel a reluctance to pass multi-lane roundabouts .

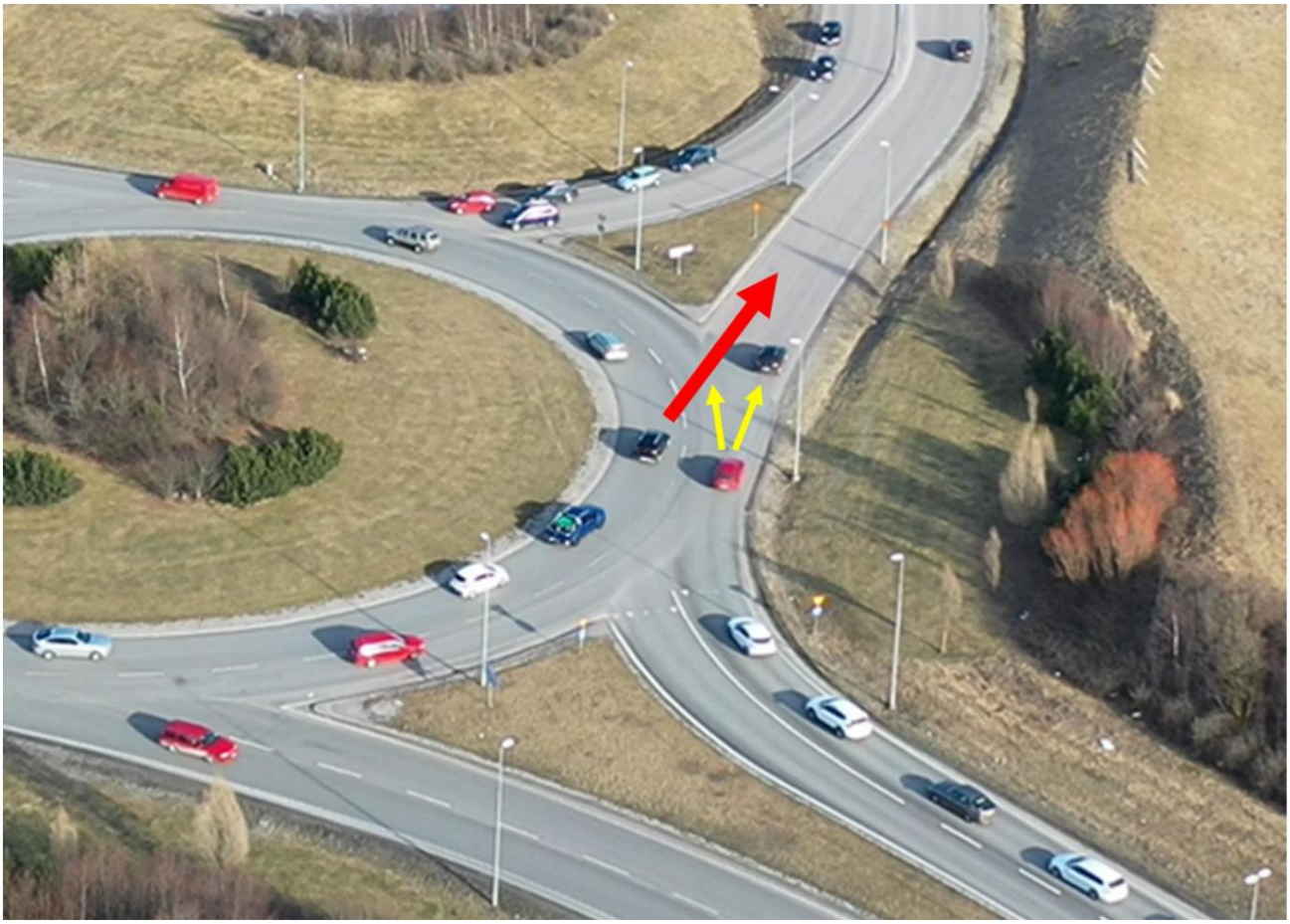


Excerpt from one of WSP's drone videos shown in the web presentation. In this case, the passenger car must brake strongly for the truck. Since it is the passenger car that changes lanes from the inner to the outer lane, it is this driver who would have been considered at fault in the event of an incident in this situation.



Excerpt from one of WSP's drone videos shown in the web presentation. In this case, the black car has to panic brake to a standstill for the red car. Since it is the black car that makes the lane change from the inner to the outer lane, it is this driver who would have been considered at fault in the event of an incident in this situation.

Excerpt from one of the films shown in the web presentation. This video is taken from an external source, showing a roundabout in England (left-hand traffic). The film is filmed from the front of a car. The exit from the circulation has two lanes, where the red car travels from the inner lane of the circulation towards the exit, while the car filming travels in the outer lane of the circulation. In this case, the vehicles collide, resulting in the red car overturning and ending up in the ditch. However, it should be borne in mind that this type of a little more serious accidents are not common in roundabouts.



Excerpt from one of WSP's drone videos shown in the web presentation. In this case, the black car has chosen to remain in the inner lane all the way to the exit (red arrow). Unless the driver has to take an extra turn in the circulation, he "must" change from the inner to the outer lane here (to travel towards the exit) and thus has to "expect" that the red car will also turn towards the exit (the right yellow arrow). If, on the other hand, the red car intends to continue traveling in the circulation (the left yellow arrow), then an incident would risk occurring. Since it is the driver of the black car who changes lanes, it is this driver who would be considered at fault in the event of an incident, which makes the situation even more complicated.

5. Introductory description of the Hassel circle

This chapter summarizes the information from the webinars that WSP held in November 2021, where the concept of the Hassel Circle is described. These webinars are available on YouTube, search for "Hasselcirkeln" (direct link: https://youtu.be/jsIRbur-VYTE). If you look at these webinars, you have to keep in mind that some of the discussions can now be seen as out of date, as certain questions have been investigated further after the webinars were conducted (and as described in later chapters). This applies above all to the discussion that was held about the fact that it would probably not be possible to sign a Hassel circle as a circulation area in view of the traffic regulations, and that there would be a difficulty in creating a good environment for U-turning traffic to safely carry out the turning movement into the new inner lane.

5.1. Why a Hazel Circle?

The two main purposes of a Hassel circle are to reduce the number of conflict points and to use unused capacity, in both cases compared to today's multi-lane circulation places. The idea is to create a basic solution based on the four-step principle that provides great benefits in a cost- and surface-efficient manner. In most cases, a Hasselcirkel also does not involve very large reconstructions from an existing multi-lane circulation, which is why the costs do not need to be so great. Of course, you could also take the opportunity to build a roundabout according to the Hassel circle concept in connection with the fact that you still want to provide a roundabout with more lanes, or in the case of a new building.

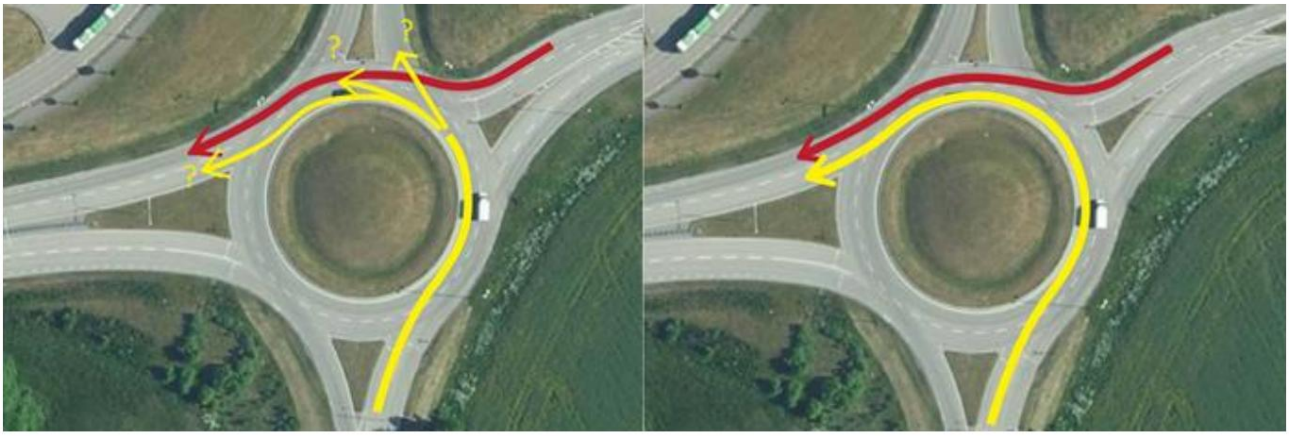
5.1.1. Reduce the number of points of conflict

Just as was mentioned in the previous chapter, there are some shortcomings in today's multi-lane circulation spaces, many linked to lane changes from inner to outer lanes. In addition to that aspect, large circulation areas, even in general, can also be experienced as partly messy, with large areas without clear divisions.

5.1.2. Use unused capacity

In today's circulation areas, the capacity that actually exists in certain relationships is not used. This is explained in the images below that show typical examples.

Example 1: A car turning right also gives way to vehicles that are in the inner lane. Actually, they could have run parallel, whereupon the passability could potentially have increased, as there are two lanes towards the exit in this case.



Example 2: A driver going straight ahead according to a red arrow gives way to a car according to a yellow arrow. If the yellow car is going west, the two vehicles could have driven parallel, which could have potentially increased accessibility.

Example 3: Two fields are not always used in practice with today's design, which is why painting has sometimes taken place. In this type of location, there is potential in using the two existing fields with a different design, which can increase accessibility.

5.2. What is a Hazel circle?

A Hassel circle means a different type of painting/dividing the lanes in the circulation, where inspiration has been taken partly from turbine-painted roundabouts and partly from Turbo roundabouts, which are most common in the Netherlands.

In general, it can be said that the Hassel circle is based on the driver choosing a lane before entering the roundabout. The driver gives way to the traffic that is already inside the circulation in a similar way as today, although in practice the driver does not always have to give way to the traffic that is in the inner lane, see the sketches further down.

Once you enter the circulation, you can then stay in your lane all the way to the exit. You therefore do not need to change lanes from the inner to the outer to get out towards the exit, as you often have to do in today's multi-lane roundabouts.

When making a U-turn, you can actively change a lane to the left inside the circulation, in a place where a new lane grows out to the left. At this location there is a sudden/transverse angle change ("kink") on the left side of the lane, which causes the road user to be enticed to continue in his lane, rather than continuing to follow the inner edge. If, on the other hand, you have to make a U-turn, you must actively turn to the left after this angle change. This is one of the differences compared to a turbine-painted roundabout, as a sudden/transverse angle change is usually not found in one, which is why motorists there risk being enticed to continue closest to the inner edge.

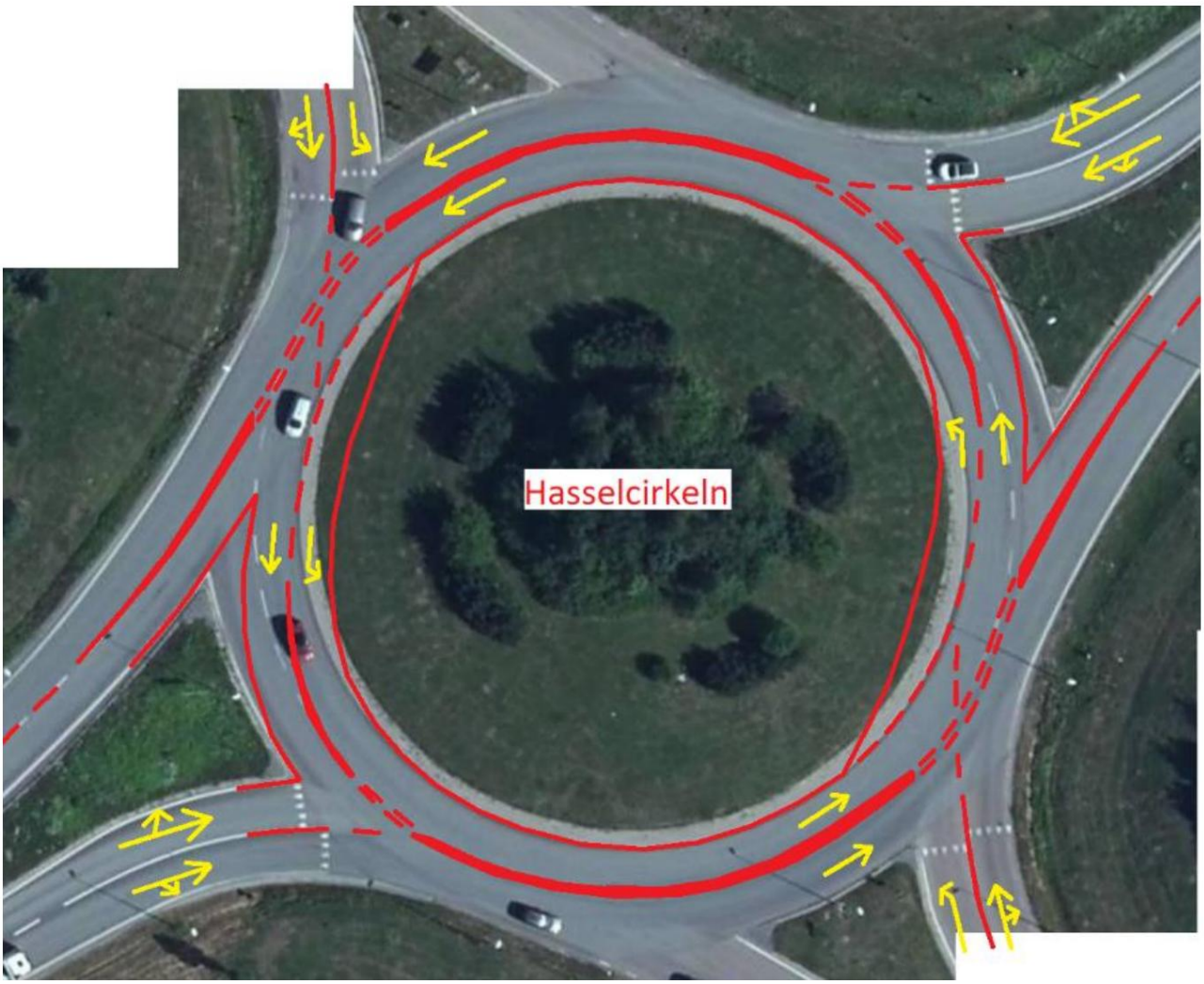
Between the inner and outer circulating lanes there is a divider that prevents the driver from changing lanes. This is a feature similar to Turbo roundabouts, although there are some other differences to one, including the ability to complete a U-turn.

Here below, various sketches are first shown that show what a Hassel circle is, while comparisons with turbine-painted circulations and Turbo roundabouts are made in later chapters.

Even if a unique design of the Hassel circle would have to be made for each specific circulation location, the concept can still be described based on some typical sketches. Here below, a concept sketch is first described for a large circulation (inner diameter from about 40 meters and up), for a smaller circulation (inner diameter about 30 meters), and for a circulation where, for various reasons, you can only implement the Hasselcircel concept to a certain extent .

5.2.1. Concept sketch large circulation area 1

The existing circulation in this case has a main direction between east and west, with dual lanes in both directions. The design of the Hassel circle in this case contains the same lane division and number of lanes in different relationships, as today's circulation.



Concept sketch for large circulation area. The specific circulation in this case has a main direction between east and west, with double through lanes in both directions.

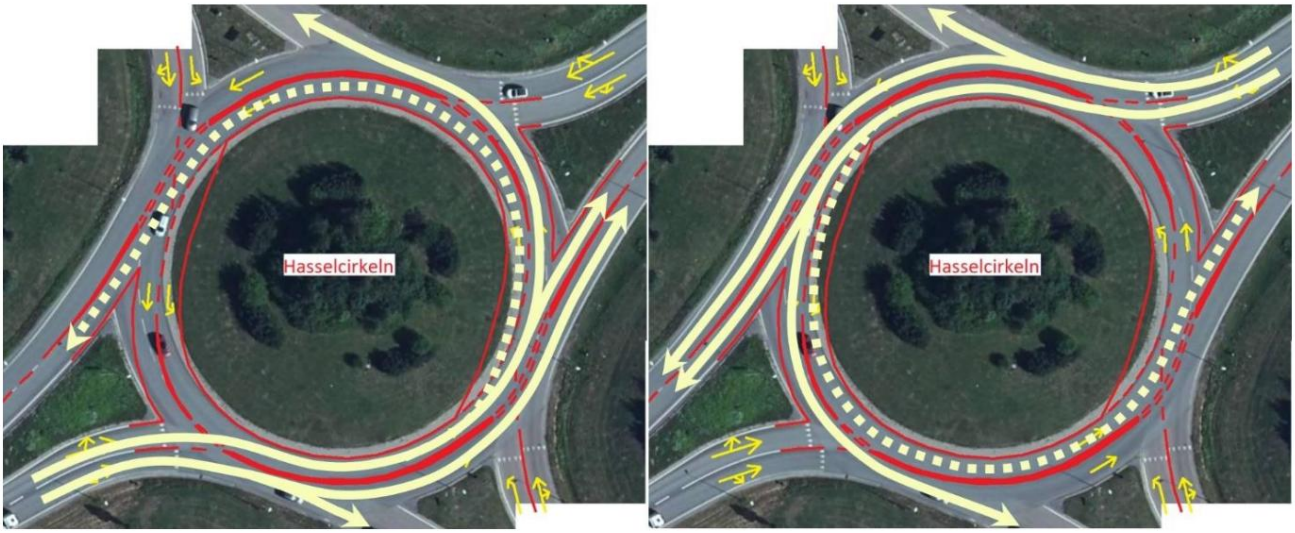
For the circulation area in the sketch above, the current design applies:

28 conflict points of which 4 lane changes from inner to outer field

With the Hassel circle drawn above:

18 conflict points of which 0 lane changes from inner to outer field

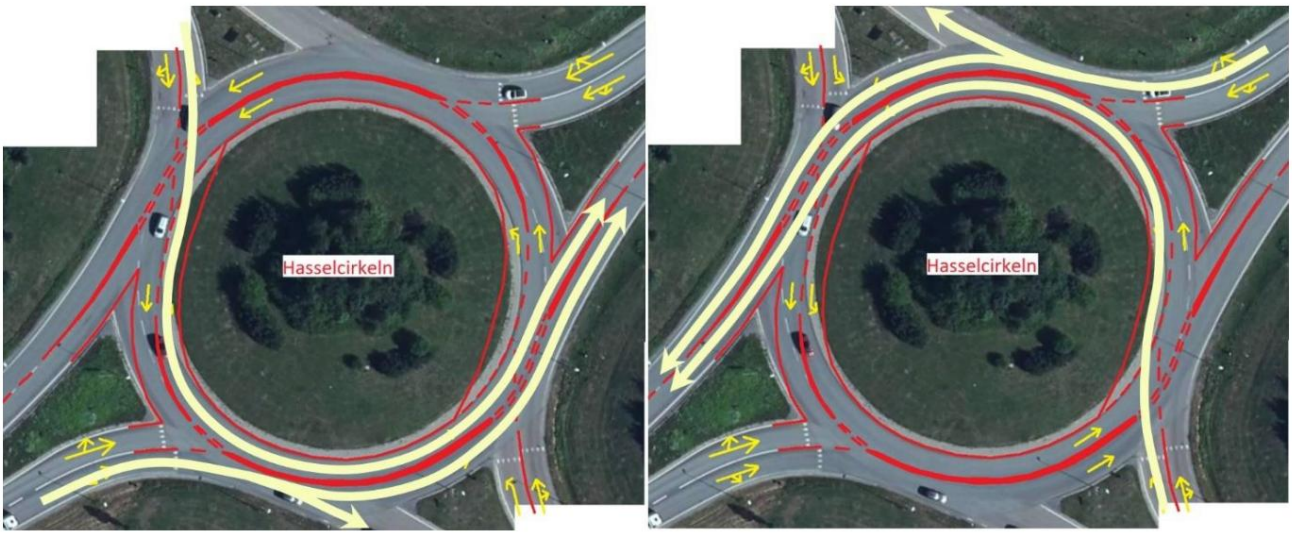
The following pictures show how to drive in different directions. Dashed beige line is U-turn.



Traffic entering the circulation from the west and east, i.e. the two main directions in the circulation (with double lanes straight ahead).

The traffic entering the circulation from the north and south respectively, i.e. the two side roads.

The following images show examples of relationships that in practice can run concurrently. With today's design, corresponding relationships need to interact with each other (where the traffic from the connecting road today therefore needs to go).



Examples of relationships that in practice can run simultaneously.

Examples of relationships that in practice can run simultaneously.

Worth noting is that it is not intended that there should be any special additional board or similar that informs road users who join the circulation about which lanes they need to move into, but it should still be the drivers who join who need to assess which vehicles they need to make way for.

5.2.2. Concept sketch large circulation area 2

A concept sketch for another large circulation area is shown here. In this case, today's design is of such a nature that there is hardly any need to go outside the current road path when repainting/rebuilding to the Hasselcirkel concept. In this circulation there is a main direction between north-west and south-east, with double lanes in each direction. In this case, the design of the Hassel circle contains the same lane division and number of lanes in different relationships, as today's circulation.

Concept sketch for large circulation area. The specific circulation in this case has a main direction between northwest and southeast, with double continuous lanes in both directions.

For the circulation area in the sketch above, the current design applies:

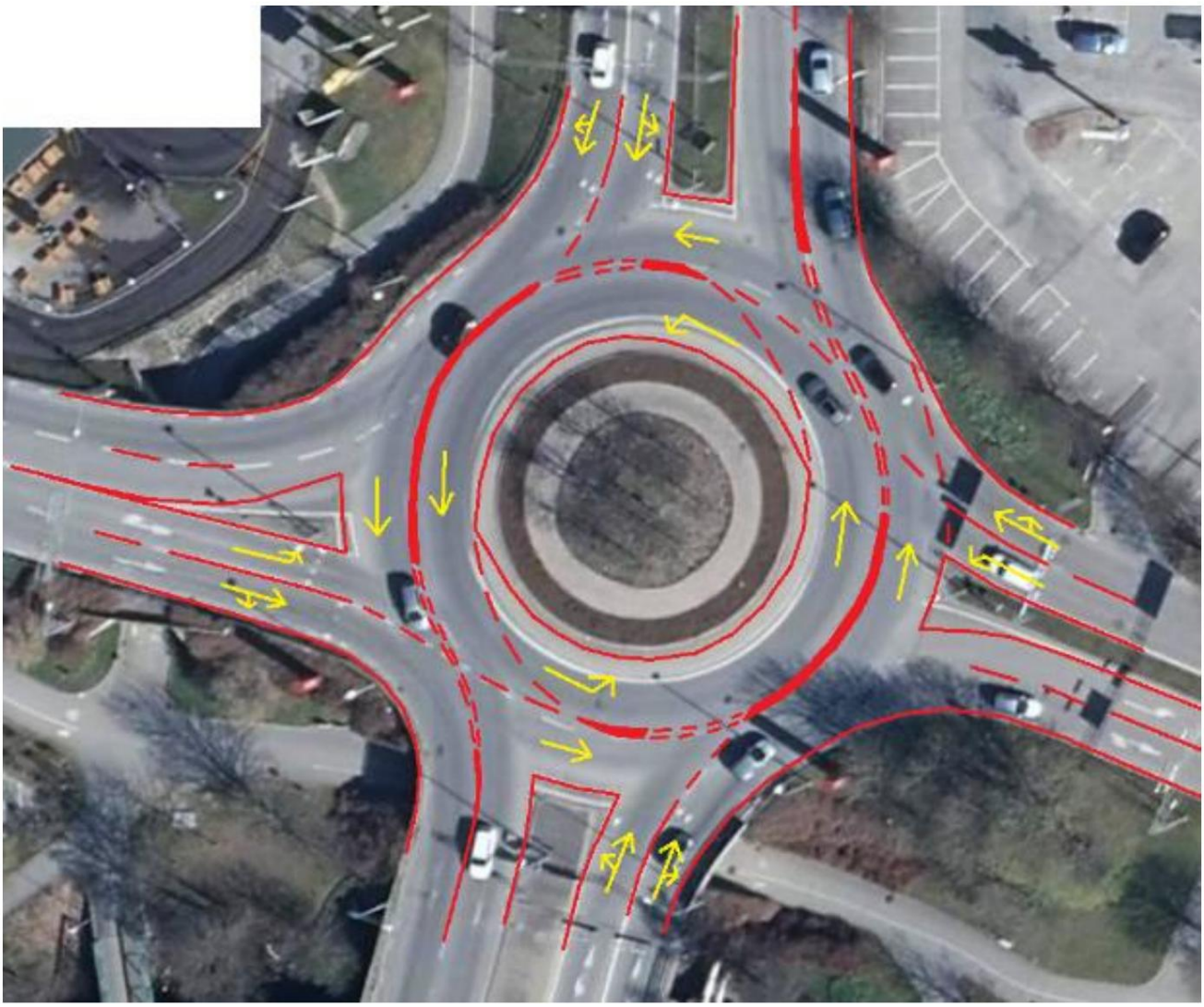
28 conflict points of which 4 lane changes from inner to outer field

With the Hassel circle drawn above:

16 conflict points of which 0 lane changes from inner to outer field

5.2.3. Concept sketch less circulation

The existing circulation in this case has a main direction between north and south, with dual lanes in both directions. The design of the Hassel circle in this case contains the same lane division and number of lanes in different relationships, as today's circulation.



Concept sketch for smaller circulation space. The specific circulation in this case has a main direction between north and south, with dual through lanes in both directions.

For the circulation area in the sketch above, the current design applies:

28 conflict points of which 4 lane changes from inner to outer field

With the Hassel circle drawn above:

18 conflict points of which 0 lane changes from inner to outer field

5.2.4. Concept sketch less circulation (with only partial measures)

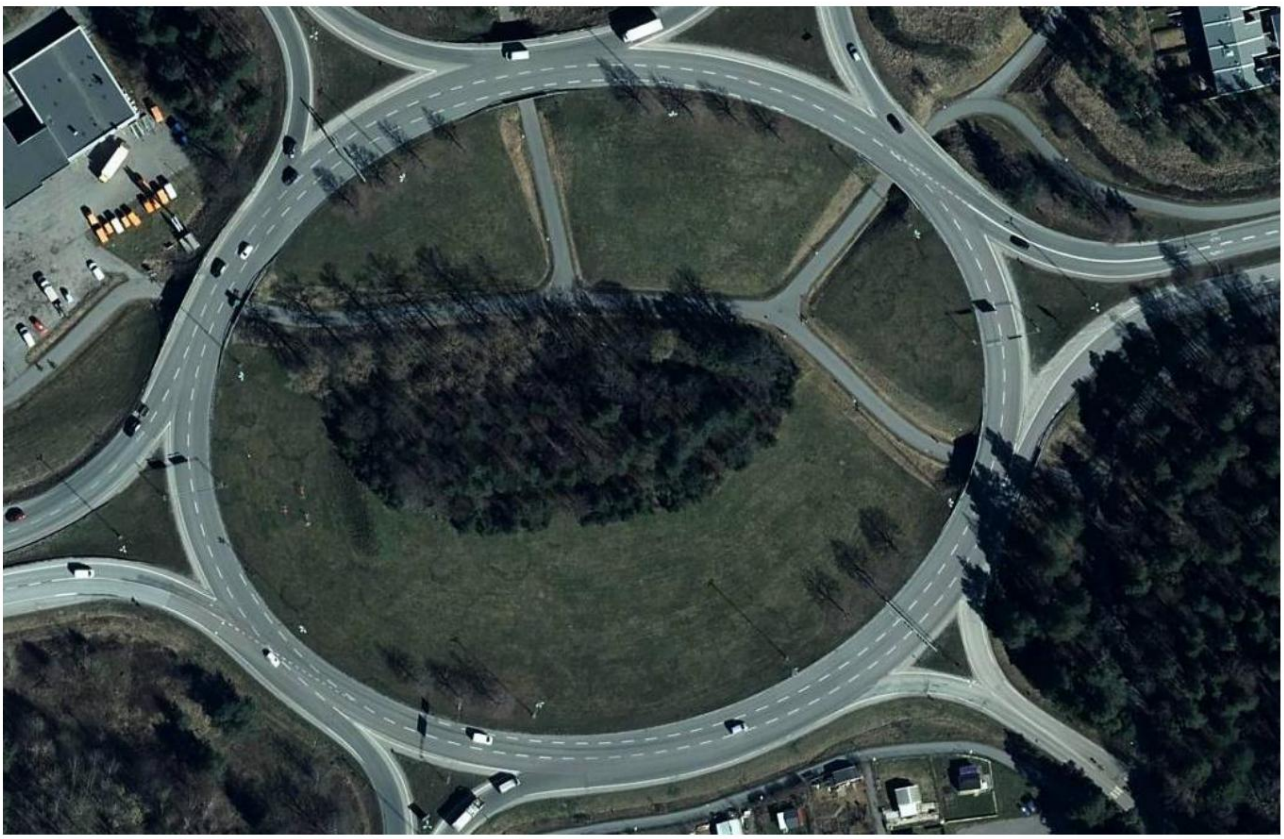
In the existing circulation in this example, there is only the possibility of implementing the solution in a part of the circulation. In this case, traffic in the right lane from the south (black arrow) can drive straight ahead at the same time as traffic turns left towards the north (light blue arrow).

Some drivers will probably be a little careful anyway (black arrow), but accessibility should still increase compared to if even the right lane from the south (black arrow) were to give way fully to traffic from west to north (light blue arrow).

Concept sketch for examples of circulation where it is only possible to implement the solution in part of the circulation.

5.2.5. Comparison with turbine-painted roundabouts

Today, some roundabouts in Sweden are painted with turbines. In these cases, the lanes lead out from the circulation, rather than there being two lanes around the entire road, and the lanes gradually growing out from the inner edge. Inspiration from turbine-painted circulations has been taken for the Hasselcirkeln.



Example of a turbine-painted circulation area.

Another example of turbine painted circulation space.

In turbine-painted roundabouts there is no sudden/transverse angle change that helps the driver into the "correct" lane where a new lane grows out from the inner edge. This allows the drivers may become unsure of how it is intended to drive. Should you continue towards the inner edge or should you follow the turbine painting? If the drivers choose to follow the turbine painting, they may feel uncertain about whether they now risk coming into conflict with vehicles that are in the outer lane (to the right of). Relatively often, the turbine painting also wears out, which means that the circulation in practice can be more similar to the painting that prevails when two lanes are painted around the entire road.

In the Hassel circle, the sudden/transverse angle change helps to make it clear to the road user that he should not continue along the inner edge. Nor does the driver need to feel uncertain about whether he will get in the way of vehicles that are in the outer field (to the right of) because there is a clear demarcation towards this field. Since the sudden angle change inside is provided with curbstone, there is also not the same risk that the function disappears over time, as a turbine painting risks doing if the line wears out. The angle change will remain anyway.

Another clear difference between the turbine-painted circulation space and the Hassel circle is that it is possible to change lanes between the inner and outer fields everywhere in a turbine-painted circulation space. This in turn means that the improvement in accessibility that occurs in the Hassel circle thanks to the fact that you do not always have to give way in practice for the inner circulating lane is not found in turbine painted circulations, but in that respect the turbine painted circulation works in the same way like normal circulations.

Example of turbine painting, where a line gradually increases in distance from the inner edge. On the right, you can see that the line has been worn, and in this situation the drive can in practice be like a regular multi-lane roundabout. Since a turbine-painted roundabout lacks a sudden/ transverse angle change where the new lane begins, the driver may be unsure whether to continue along the inner edge or whether to follow the line that grows out. If you follow the line that grows out, you may also be unsure whether you will come into conflict with a driver who is in the outer lane (to the right of).

5.2.6. Comparison with Turbo roundabouts

Turbo roundabouts have existed in the Netherlands since the year 2000 and are also found in other places, such as in Eastern Europe and Canada. Several studies have been done where it has been seen that the capacity increases, the number of incidents decreases (by approximately 72%), and that the average speed in the circulation decreases (which makes it easier for connecting traffic to find a gap).
Turbo roundabouts generally require larger rebuilds than a Hassel circle would and do not always allow U-turns.

With regard to the conclusions drawn for Turbo roundabouts, however, the assessment is that these should at least to some extent also apply to Hasselcirkeln. This applies, for example, to the increased capacity (in practice you don't always have to give way for the inner circulating lane), and that the number of incidents decreases (you don't have to change from the inner to the outer lane when you leave the circulation).

Typical appearance of a Turbo roundabout. Where the new inner lane begins, the idea is not for vehicles to turn into those already in the circulation, which means that U-turns are not always possible in Turbo roundabouts.

A drone footage of a Turbo roundabout shows that the drivers understand that in practice you don't always have to give way to the inner roundabout. The same is also seen in the Munkebäcksmotet in Gothenburg, where one of the entrances has a design that partially resembles a Hassel circle where you don't always have to give way for the inner field (see further in later chapters where comparisons with the Munkebäcksmotet are made).

5.3. Potential effects?

In a general VISSIM run with typical flows, the capacity increases by approximately 22% if you compare the same circulation location based on today's design and with the Hassel circle. However, local factors for the specific location will influence how much capacity increase can be expected, among other things based on how big the flows are in different relationships, how big the circulation is, etc.

Below is a snapshot from microsimulation from a real location with today's design and today's flows. Underneath this picture, the conversion to the Hassel circle can be seen, but otherwise with the same conditions (same diameter, same number of lanes, etc.). It is clearly visible that the queues are shorter with the Hasselcirceln.

Fewer points of conflict should also result in a reduced number of incidents, which is also confirmed by the studies carried out by Turbo roundabouts. In congested situations, increased accessibility can mean a reduced risk of queues, which can indirectly mean a reduced number of overtaking accidents. On streets with bus lanes, the bus lane ends in many cases a bit before the circulation and where the bus is allowed to travel through it in mixed traffic. With this design, the bus can thus have a shorter journey time if the queues towards the circulation are reduced. It is therefore not only about increasing accessibility for car traffic, but applies to all types of traffic (including, for example, buses, trucks, etc.).

If the situation in today's roundabout is judged to be unsustainable, a conversion to the Hassel circle could possibly be an alternative to building something larger, such as a traffic place, where a Hassel circle is said to be significantly cheaper than building a larger solution, in general terms.

Snapshot from a microsimulation of real site with real flows.

Snapshot from a microsimulation of the same circulation site with the same flows and the number of lanes, albeit with a rebuild according to the Hassel circle (in the sense that you don't always have to give way to the inner circulating lane in certain relationships). The snapshot is from the same simulation second and based on the same random seed.

6. Further discussions and comparisons with other locations

This chapter describes the further discussions that took place after the webinars in November-November 2021, partly based on WSP's own thoughts and partly based on received views. Comparisons are also made with other existing locations. This chapter summarizes the information highlighted in the web presentation produced by WSP which deals with further discussions and which is available on YouTube, search for "Hasselcirkeln" (direct link: https://youtu.be/XXmLf2wwm4Y).

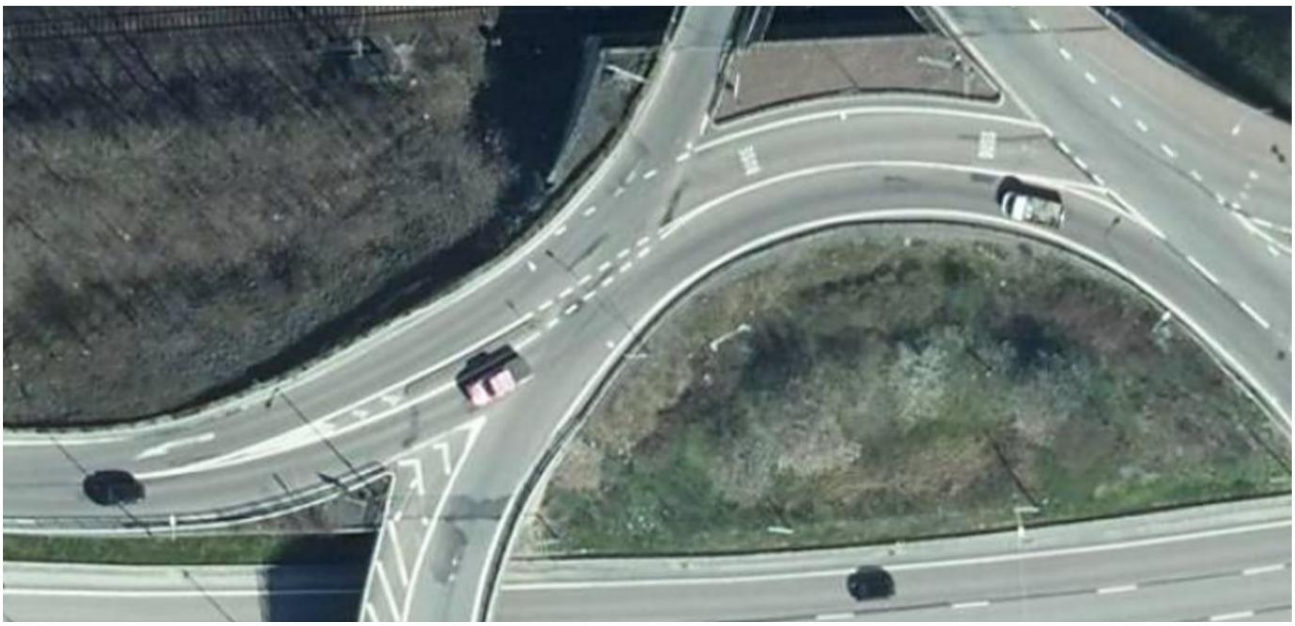
6.1. Will road users understand the lane division in circulation?

One of the views received after the webinars has been about how likely it is that road users will understand that you may not change lanes between inner and outer circulating lanes. In order to answer this, comparisons have been made with other places, including the Mun-kebäcksmotet in Gothenburg, where the north-western part of the circulation has a similar design to the Hassel circle, with a solid line between the inner and outer fields, and where the traffic from connecting road should not always need to road for inner field.

As also mentioned in later chapters, the discussions between the Swedish Transport Administration and WSP have led to the conclusion that the most suitable design should be to only have painted dividers between inner and outer fields inside the circulation (preferably barrier field/barrier area), but where there is a shelter between the lanes on the way out of the roundabout (in cases where the exit has two lanes). With that as a starting point, it is required that the road user, despite only a painted divider inside the circulation, must understand that you are not allowed to change lanes. In addition, it is desirable that drivers connecting to the circulation should understand that in some cases they do not need to give way to the inner circulating field (otherwise you will not get the desired capacity increase). For these reasons, it is of interest to compare with other places, see further below.

6.1.1. Comparison with the northwestern part of the Munkebäcksmotet

In the north-western part of the Munkebäcksmotet roundabout there is a design of the roundabout which is similar to a Hassel circle.



Aerial view of the north-western part of the Munkebäcksmotet circulation area. At the height of the pink car, there is a shelter between the two lanes leading to the left in the picture.

View from the north from the connecting road.

Drone image of the northwestern part of Munkebäcksmotet's circulation area (north is to the right in the image). Below texts refer to this image.

Based on the drone image above (the lower of the three images above): Below the red circles in the image is a solid line between the inner and outer circulating fields. This is thus a property similar to a Hassel circle. On the on-ramp up in the picture, there are two lanes (coming from the inner and outer circulating lanes), where these are separated by a shelter for a short distance. From the connecting road to the right in the drone image, it is an advantage if road users understand that they do not have to give way to the traffic traveling in the inner lane when turning right (towards the on-ramp upwards in the image). If, on the other hand, the connecting traffic from the right in the image is to continue into the circulation to the left in the image, they need to give way for both inner and outer fields. Just as for the Hasselcircel concept, the traffic traveling in the inner circulating field needs to understand that they must stay to the left of the refuge towards the on-ramp in the image above.

Based on WSP's drone films (see the web presentation on YouTube where, among other things, a drone sequence from Munkebäcksmotet is shown approximately 8 minutes into the film, direct link: https://www.youtube.com/watch?v=XXmLf2wwm4Y#t=08m00s) it is clearly visible that traffic from the connecting road (from the right in the picture) which is to turn right is driving at the same time as traffic is traveling in the inner circulating field. The drone image above (the two red circles) also shows this, where the upper circle shows a car that has just passed the turning line from the right in the picture, while a car is traveling in the inner field (the second circle). The vehicles that from the connecting road, on the other hand, must continue into the circulation (to the left in the picture) understand that they must give way to both the inner and outer circulating field. Furthermore, it can be clearly noted from the drone footage that the vehicles that are in the inner circulating field understand how to drive towards the on-ramp (up in the image), i.e. that they should stay in their lane and thus drive to the left of the refuge. This design has existed for many years and there has also been no information that motorists do not understand how to drive here when there is snow on the road, or in similar conditions.

The conclusion of this comparison with the Munkebäck pattern is thus that this type of design where you only have painted dividers between inner and outer lanes inside the circulation should work. Having a refuge between the lanes on the way out of the circulation is deemed to make it easier for road users to understand how to drive, which is why it is also proposed for the Hassel circle, see further in later chapters.

Just as for the Hassel circle, the Munkebäck road in this case also has an "opening" in the separator between the inner and outer fields (at the place where traffic from the connecting road must

drive in to get further into the circulation). As can be seen in the pictures above for the Munke-bäcksmoet, this "opening" consists of double dashed lines (opening in the barrier area), where a similar solution is proposed for the Hassel circle. In the Munkebäck roundabout, there is only one solid line between the lanes closest to this "opening", but as described in later chapters for the Hassel circle, a barrier lane/barrier area is proposed in the first instance. This means that the dashed lines at the "opening" in the Hassel circle also have a greater distance between each other than they have in the Munkebäck pattern, which is seen as an additional advantage in the Hassel circle than in the Munkebäck pattern. But even for the Munkebäck road, it works well, where the traffic understands how to drive in the different relationships.

6.1.2. Comparisons with other places where a solid line needs to be understood

Also in other places in the road network, there are several places where only a painted divider (for example a solid line) needs to be understood by road users, even in winter road conditions.
In roundabouts the speeds are also relatively low, which is why it is rather in other places that serious accidents would potentially risk occurring if painted dividers (for example a solid line) were not understood by road users. Here are some examples from places in Sweden where one could potentially think that there should be a risk of what could happen if solid lines were not followed, but where reality shows that they work well. These places are highlighted to demonstrate that if only painted dividers are used and in practice work in other places, it should also work in circulations.

Typical approach on a 2+1 road, where the approach becomes K1 further ahead.

This design is common in Sweden and generally accepted. If a vehicle coming driving on the main road were to fail to understand the solid line, there would be a potential risk of the vehicle coming too far to the right on the on-ramp and ending up in the right lane in whole or in part. A vehicle can arrive here at the same time

which has just turned off the driveway. This type of design is generally accepted and works, which proves that the painted divider in this case is understood by road users. In this case, there would also be a much greater risk of serious accidents than in a circulation area if an incident were to occur, considering the speeds.

Obligation to give way onto the primary road, where the idea is only that the traffic that gives way should do so against traffic in the farthest lane (as it is a solid line towards the other lanes).

Even in this case, road users need to understand the solid line between the lanes, where a serious accident could potentially occur if this is not done. Even in this case, the risks of a serious accident would also be much greater than for a circulation site, given the speeds.

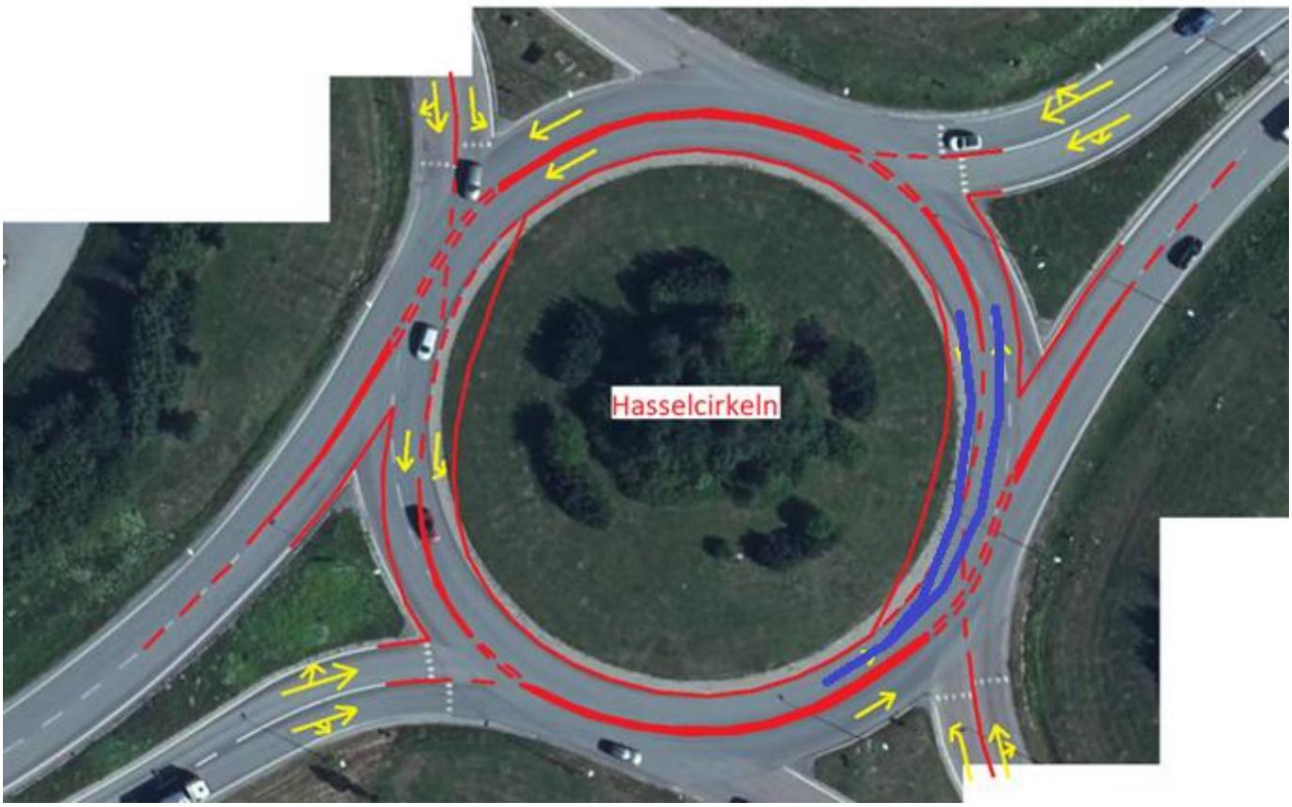
Free right turn in a roundabout.

Although it is not a standard design to design a free right turn in a circulation site without a separating refuge, it still occurs in some places. In this location, the solution has existed for about 10 years. In this case there is a potential risk that vehicles that

coming from the left in the picture (from inside the circulation) who are going in the same direction as the truck do not understand that they should stay in the left lane into the exit road, without instead would continue into the right lane (in the lane where the truck is driving). Since the traffic in the free right is not obliged to turn, in this case it can be reasoned that the risk of accidents would also be greater than for the Hassel circle, because all traffic in the Hassel circle is obliged to turn.

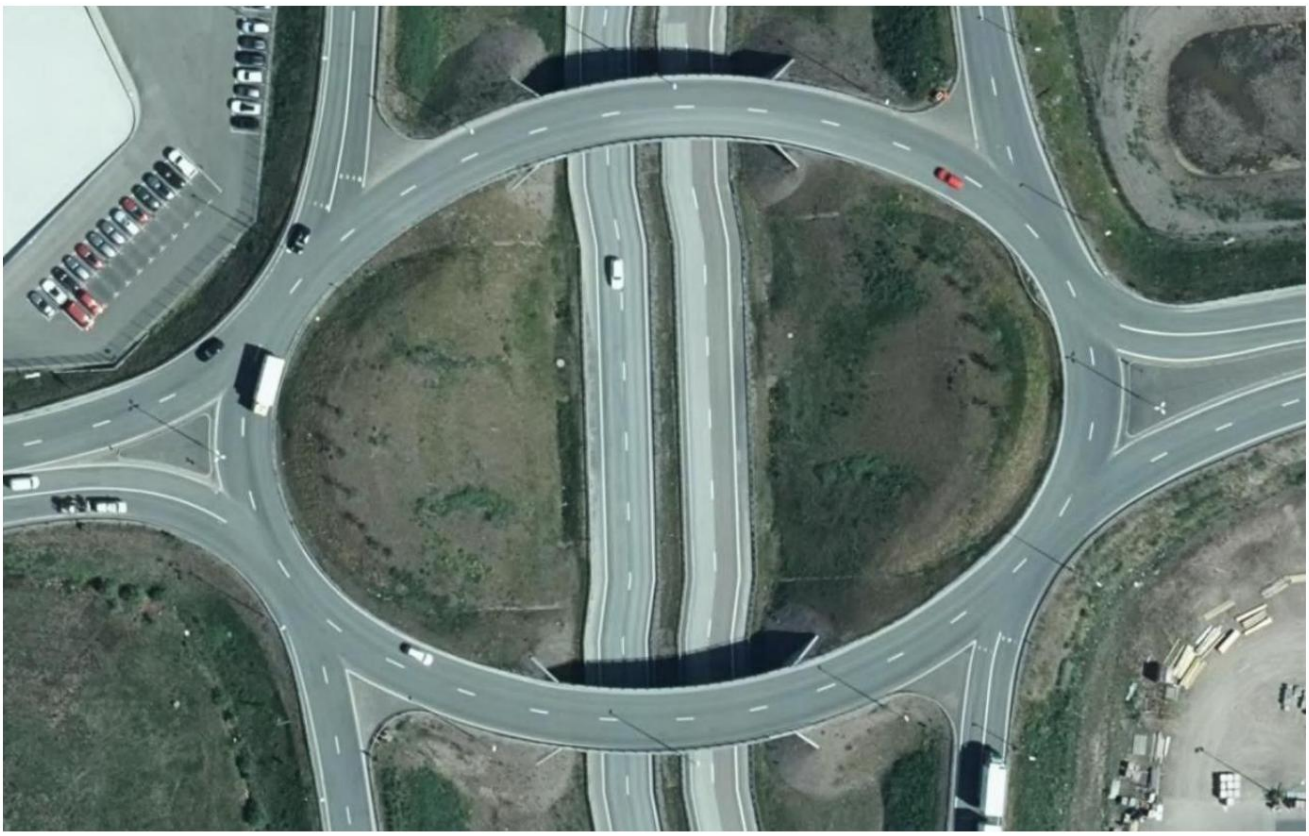
6.2. Risks of departures for U-turning traffic?

Another point of view received concerns whether there may be a risk of a too narrow radius where U-turning traffic has to change into the additional inner field. However, the assessment is that there is no such risk, as long as you make the distance you have to switch in long enough. Even if there is a sudden/transverse angle change right where the new inner lane begins, the driver does not need to make a corresponding transverse angle change, rather cannot smoothly turn into the new lane. If you compare the two blue lines in the image below, you will see that it is only a slightly tighter radius that it means to turn into the new inner lane, compared to staying in your lane.



Comparison between turning radii. It just means a slightly tighter radius to turn into the additional inner lane (for U-turns) compared to continuing to follow the lane.

You can also draw parallels to oval roundabouts, of which there are more and which are also generally accepted. Even in these, the radius inside the circulation changes.
A good example is the relatively newly built circulation in Tpl Rebbelberga in Ängelholm.



Example of an oval roundabout, where the radius changes inside the roundabout, Tpl Rebbel-berga in Ängelholm.

7. More precise design issues

This chapter describes the issues that were discussed between different competences within the Swedish Transport Administration and with WSP during the beginning of the year 2022.

7.1. Traffic regulations for roundabouts

During the webinars in November 2021, views were expressed that claimed there could be a risk that the Hassel circle would be in violation of the traffic regulation for roundabouts. The listener who raised this had in mind that the regulations state that the driver must give way to both the circulating fields. During the webinar, it was discussed that a possible solution to this could have been to not sign Hasselcirkeln as a circulation site, just as a drop is also not signposted as such.

However, traffic engineers at the Swedish Transport Administration have checked this in more detail during the beginning of 2022 and concluded that Hasselcirkeln can be signposted as a circulation place, based on what the traffic regulation says.

Trafik i en vägkorsning m.m.

20 § När en förare närmar sig eller kör in i en vägkorsning, skall körsättet anpassas så att det inte uppstår onödigt hinder för trafiken på den korsande vägen, om fordonet tvingas stanna i korsningen.

21 § En förare som från en väg kör in på en annan väg som är huvudled, motorväg eller motortrafikled och där accelerationsfält saknas, har väjningsplikt mot fordon på den väg föraren kör in på. Väjningsplikten gäller dock inte där föraren kommer in på huvudleden, motorvägen eller motortrafikleden utan att byta körfält.

En förare har också väjningsplikt mot varje fordon vars kurs skär den egna kursen när föraren kommer in på en väg
1. från en parkeringsplats, en fastighet, en bensinstation eller från något annat liknande område i anslutning till vägen,
2. från en stig, en ägoväg eller någon annan liknande utfartsväg,
3. från en cykelbana, en gågata, ett gångfartsområde, en cykelgata eller från terräng, eller
4. efter att ha korsat en gång- eller cykelbana.

En förare har dessutom väjningsplikt mot fordon på en körbana när föraren kommer in på den från en vägren eller från en sådan cykelbana som är en del av vägen.

Väjningsplikten enligt första och andra styckena gäller inte cyklande och förare av moped klass II som ska korsa en körbana eller cykelbana på en cykelöverfart. Förordning (2020:842).

22 § En förare som kör in i en cirkulationsplats har väjningsplikt mot varje fordon som befinner sig i cirkulationen.

3 kap. Bestämmelser för trafik med fordon

Gemensamma bestämmelser

1 § Fordon får inte föras av den som på grund av sjukdom, uttröttning, påverkan av alkohol, andra stimulerande eller bedövande ämnen eller av andra skäl inte kan föra fordonet på ett betryggande sätt.

2 § Avståndet till ett framförvarande fordon skall anpassas så att det inte finns risk för påkörning om det saktar in eller stannar. Avståndet skall också anpassas så att andra trafikanters omkörning underlättas.

3 § När ett fordon eller en spårvagn är i rörelse får på- eller avstigning inte ske. Inte heller får någon färdas på fordonets eller spårvagnens fotsteg eller liknande anordning, om den inte är särskilt inrättad för detta.

4 § Den som åker kälke, sparkstötting eller liknande fordon eller som åker skidor, skridskor, rullskridskor eller liknande på väg får inte låta sig skjutas på eller tolka, dras eller låta sig dras av ett motordrivet fordon eller en spårvagn.

På ägovägar eller liknande vägar med ringa trafik får dock tolkning ske.

5 § Förare som har väjningsplikt skall tydligt visa sin avsikt att väja genom att i god tid sänka hastigheten eller stanna.

Föraren får köra vidare endast om det med beaktande av andra trafikanters placering, avståndet till dem och deras hastighet inte uppkommer fara eller hinder.

Extract from the traffic regulation (1998:1276).

If you first read section 22 (circled on the left), it appears that a driver who gives way into a roundabout must give way to all vehicles that are there. Nothing specific about "both inner and outer lanes" or the like is not mentioned. However, it is not possible or necessary to give way to all vehicles in the circulation area, which is why you have to look further in paragraph 5 (circled on the right). This shows that when turning, you must take into account the location of other road users, the distance to them and that there is no danger or obstacle.

Based on this, it can be concluded that a vehicle that is to enter the circulation area may drive in unless there is any danger or obstacle for the vehicles that are already in the circulation. Thus, the assessment is that a Hassel circle does not contravene the traffic regulation. A driver who is obliged to give way has a continuing obligation to give way to everyone

vehicles that they need to give way to, but in practice do not need to give way to a vehicle in the inner circulating field if this is separated by a solid line or barrier field (like the Hassel circle and already today the Munkebäcksmotet). This, of course, on the condition that the driver who gives way must not cross his lane. This is how it already works today in the north-western part of the Munkebäcksmotet (see previous chapter). Here, too, there is an opening in the barrier field, like a Hasselcirkeln is proposed to have. The opening itself is thus no obstacle to this.

However, it is important to take into account that, formally, the driver who is weighing has continued to be obliged to give way for the entire circulation, which is why formal texts, etc. should also not state that the driver who is giving way does not have to give way for the inner circulating field. As it seems based on drone footage, road users still understand this in Munkebäcksmotet. Overall, the assessment is that the Hassel circle does not contravene the traffic regulation.

7.2. Permission to travel in outer fields as far as you want?

A question that has been discussed is whether there may be a problem in that in the Hassel circle it is not intended that you can drive as far as you want around the roundabout surface in the outer (right) lane of the roundabout. In a multi-lane roundabout where two circulating lanes are painted all the way around, it is allowed to travel in the outer lane even for left turns and for U-turns, despite this being contrary to practice (which has also been noted in the description of deficiencies in today's multifaceted circulations).

It has been discussed whether the above reasoning means a problem for the Hassel circle, because even in a Hassel circle it could theoretically mean that you can travel in the outer field as far as you want, i.e. for example according to the red dashed line in the sketch below. Even in a Hasselcircle, it would theoretically then be the road users who travel in the inner lane and who intend to drive towards the exit who would have to check that it is clear in the outer lane.

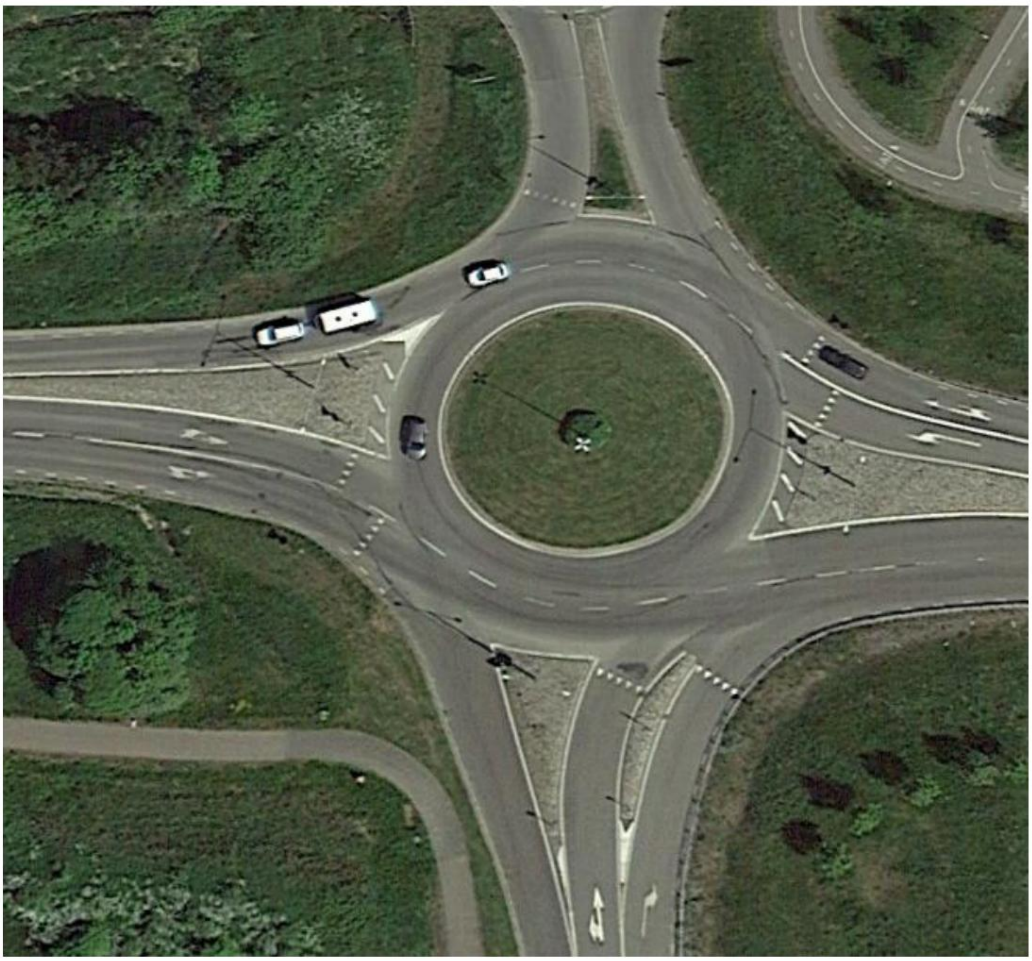
A question that has been discussed is whether the basic principle for roundabouts (which says that you should see the roundabout as a one-way road), should mean that even in a Hasselcircel you should have the right to travel in the outer lane as far as you want (and let other road users adapt sig), like a multi-lane roundabout where both lanes are painted all the way around.

However, this has been checked and nowhere in the traffic regulation does it say that, regardless of lane division, it is always permitted to travel in a circle around the roundabout as far as you want. Instead, it is the lane division that is the primary thing, where you see the lanes in the circulation as a road, which means that you can continue traveling in your lane and that it is in connection with changing lanes that you have to check that it is clear.

It is therefore not permitted to travel according to the red arrow on the sketch above and in that situation expect other road users to adapt (because this route involves a lane change, as passing through an opening in a restricted area is the same as a lane change). On the other hand, you can drive in the same way in a multi-lane roundabout where both lanes are painted all the way around, because it does not involve a lane change.

Here you can equate it to how it is on a normal road. Here too, you are not allowed to continue straight ahead, regardless of how the lanes are painted. Both in a roundabout and on a normal road, a lane can in some cases only lead to an exit and in such a situation you must not continue straight ahead past the exit from this lane, but must instead continue towards the exit, i.e. follow the lane.

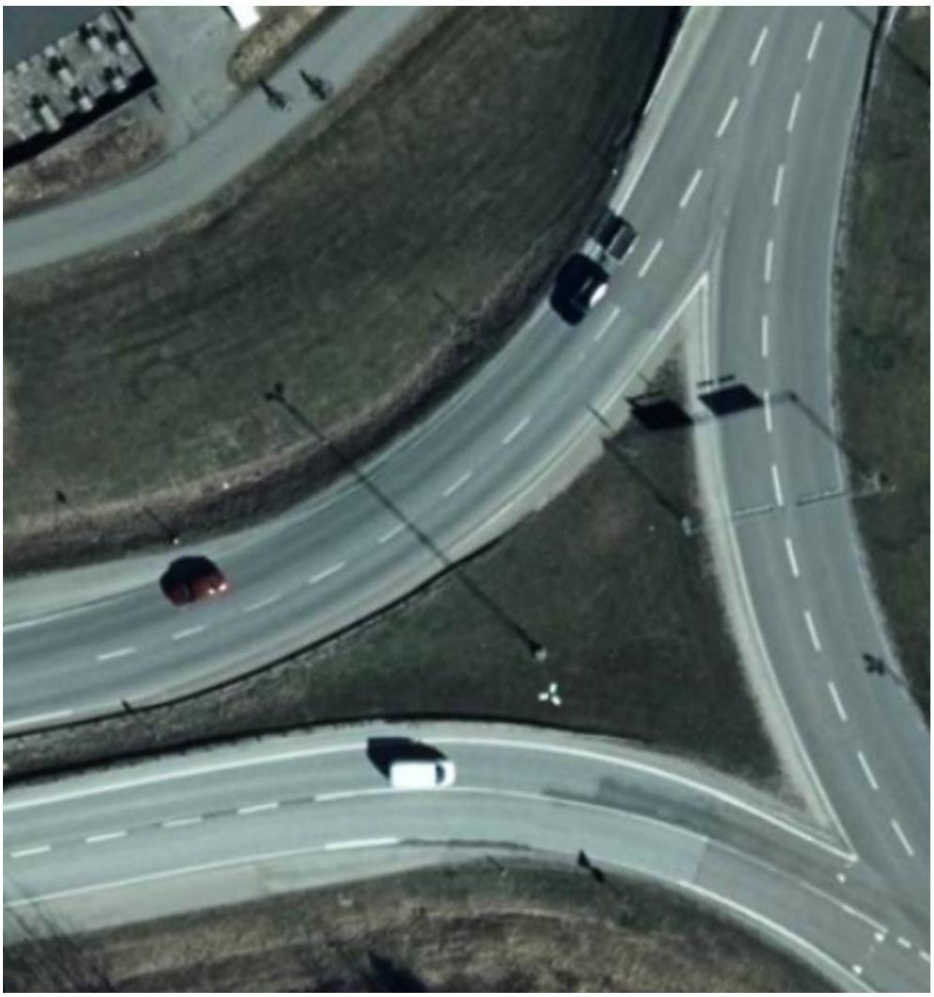
In addition, there are already today a large number of roundabouts, both newly built and older, both state and municipal, where one or more lanes only lead to an exit, i.e. both lanes are not painted all the way around. These roundabouts can thus be compared to a normal one-way road where one or more fields only lead towards the exit.



Example of a typical multi-lane roundabout where one or more lanes only lead to the exit (two lanes lead to the east exit and one to the west). This particular roundabout is relatively newly built and is on a state road.

In the above roundabout, it is not permitted to travel all the way around from the outer lane without changing lanes to the inner lane (and then checking that it is clear in this). In the same way, it would also not be allowed to do it in a Hasselcirkel because the outer lane is not painted all the way around the roundabout surface.

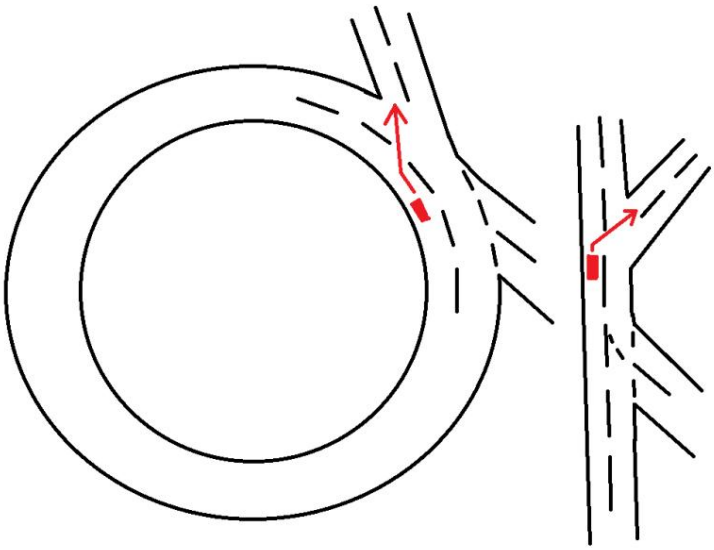
The fact that the Hassel circle would contravene the traffic regulations for roundabouts also falls partly on the basis of its unreasonableness based on the above comparison, since it would then also mean that all multi-lane roundabouts in Sweden where one or more lanes only lead to exits would also do so. It is estimated that there are several hundred such circulation points in Sweden.



Another example of a roundabout where two lanes lead towards the exit, while two lanes continue as the circulating lanes (the center lane splits you in this case). Here, too, one cannot travel in the outermost lane (at the top of the picture) and continue round the circle, but first one has to change lanes to the left in the direction of travel and then check that it is clear in this lane. Simply that you behave in the same way as on a normal road where some lanes lead towards the exit and some continue straight ahead.

This reasoning can also be explained by the simple sketches below, where for three examples one shows firstly how the lane painting is in a circulation area and secondly what this corresponds to for a normal one-way road (where straight ahead along the normal one-way road is always equivalent to continuing on around the roundabout surface in circulation).

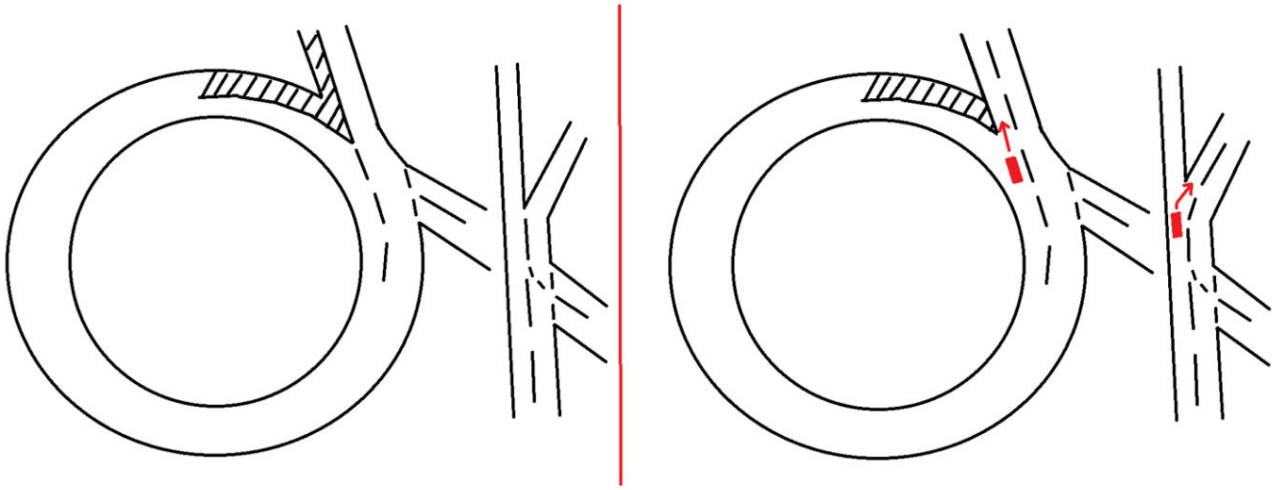
We start with **Example** 1, which symbolizes a lane painting where both lanes are painted all the way around. Here it is clear that the drawn vehicle which intends to turn out of the circulation towards the exit and which is traveling in the inner circulating lane (corresponding to the left lane on the one-way road) must give way to traffic in the outer circulating lane (corresponding to the right lane on the one-way the road). Furthermore, it is clear that you can continue in circulation even in the outer lane (corresponding to the right lane on the one-way road), without having to give way to anyone (simply because you continue to follow your lane).



Example 1.

Example of drone footage (performed by WSP) over typical multi-lane roundabout where both lanes are painted all the way around (ie is like Example 1 above).

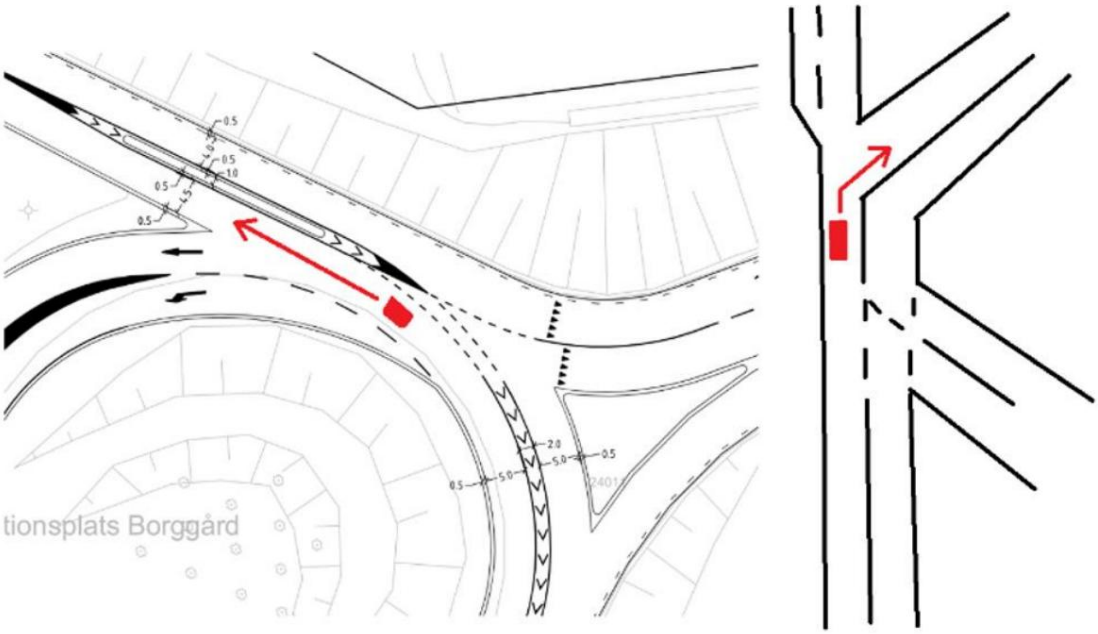
Here comes **Example** 2, which shows two typical examples of how roundabouts are also often designed today (there must be hundreds of roundabouts of this kind, both municipal and state), where one or more fields are only allowed to lead towards the exit. This design does not contravene the traffic regulations, as it is also fully permitted to lead off one or more fields only towards the exit, even on a normal one-way road. Here it is clear (both in the circulation and on the corresponding one-way road) that the drawn vehicle does not have to give way to anyone when he drives towards the exit, because he does not change lanes. Furthermore, it is clear that you may not drive from the outer circulating lane further around the circulation (right lane on the corresponding one-way road for further travel straight ahead) without changing lane to the left/inner lane and then checking that it is free here .



Example 2.

Example of drone footage (performed by WSP) over typical multi-lane roundabout where some lanes only lead towards exits (ie is like Example 2 above).

Example 3 symbolizes the Hassel circle. Here too, like Example 2, there are fields that only lead to exits. Like Example 2, this does not conflict with the traffic regulations (on a corresponding one-way road, it is also fully permitted for one or more lanes to only lead towards the exit). Here, too, it is clear that the drawn car does not have to give way to anyone traveling towards the exit (neither in the circulation or on the corresponding one-way road). Nor is it permitted to travel in the outer lane (right lane on the corresponding one-way road) if you want to continue in the circulation (straight ahead on the corresponding one-way road), as passing through an opening in a restricted area is the same as making a lane change.



Example 3.

In summary, the design of the Hassel circle does not appear to be in conflict with the legislation for roundabouts. On the contrary, there are already today a large number of roundabouts with lanes that only lead to exits and which from this aspect can be equated with the design of a Hassel circle, where not both lanes are painted all the way around the roundabout surface.

Signposting which lane one should use on the way into the circulation and at the same time having a consistent lane painting inside the circulation, where a driver does not have to change from the inner to the outer lane, should be the best design to reduce the risk of complications. Here, the Hassel circle can thus be used to advantage.

The most misleading (and thus the greatest risk of incidents) should instead be multi-lane circulations where both lanes are painted all the way around the roundabout surface. This is because the practice differs from the law with this painting in that drivers who follow the practice run the greatest risk of being at fault in the event of a lane change incident. This is regardless of whether they are signposted with information about lane selection on the way in or not.

In roundabouts where one or more lanes only lead towards exits, based on WSP's drone footage, incorrect driving behavior has not been noted in a similar way as in roundabouts where both lanes lead the entire lap. Thus, it has not been noted that drivers in these roundabouts ignore the lane selection signage on the way in and, for example, try to turn left from the outer lane (in a position where the outer lane only leads to the exit straight ahead). That the Hassel circle would become more unclear than a design where both lanes lead the entire lap is therefore not seen as reasonable to imagine.

It is also interesting to consider that if all drivers in multi-lane roundabouts with two lanes painted all the way around had only used the outer lane all the way to their exit, the capacity of the circulation would be almost as low as in a single-lane circulation, because the inner lane then had not come in handy almost at all. Such driving behavior would therefore be undesirable from a accessibility perspective.

7.3. Type of separator between the fields

Among other things, based on comparisons with the Munkebäck pattern (see previous chapter), the assessment is made that only a painted divider between the inner and outer circulating fields should work well. Both the solid line and the barred lane/restricted area are considered to work well (among other things, you only have a solid line in Munkebäcksmotet), but if you have space in the specific circulation, a barred lane/barred area is still judged to be even more advantageous.
On the one hand, a barrier lane is seen even more clearly than just a solid line and, in addition, more "wiggle room" is created between the lanes.

In addition, a barrier field allows for a large distance between the dashed lines at the "opening" in the barrier field, which is also seen as a reason why a barrier field should be used if there is room in the specific circulation instead of a solid line.

A physical divider between the lanes has also been discussed, but the assessment is that it is not necessary to have one in order for road users to understand how to drive.
In addition, there are considered to be some other disadvantages with a physical divider. Among other things, it may become more difficult for snow removal vehicles to access all lanes and "openings" between the lanes with a physical divider. With only one painted divider, snow removal vehicles can, like today, drive two laps to plow the entire circulation. There is support in the traffic regulation for snow removal vehicles to drive on restricted lanes/restricted areas, so from that aspect there is no problem that they also clear the restricted area.

In addition, there is a certain increased risk of hitting the physical divider in the event that there is snow on the ground and it is not really visible. This is because the driver is not used to a physical divider between the lanes. If the Hassel circle were to become common, in the future one could possibly consider having, for example, a refuge with granite edge supports, as the driver is already able to handle the refuge between the lanes on the way out of the circulation (which is common, for example, at GC passages). It can therefore be a certain advantage to design the barrier field wide enough that a refuge would have room to build in a possible future. However, there is still the snow removal aspect which, even for a later future, speaks for only having a painted divider between inner and outer fields.

Traffic engineers have also checked that there are no obstacles to having a restricted field/restricted area in roundabouts, which they have found nothing to say. If you would only have a solid line (which is formally a form of lane line) between the inner and outer fields, then it can only be in the form of a single line, as double lines can only be found when it is the center line. In the case of a restricted area, the detailed regulations in the Road Sign Ordinance state that "The marking consists of angled or slanted lines depending on the conditions at the site. Part or all of the area can be done in white.". It is therefore acceptable to also paint lines within the blocking area or have it completely white, which makes the blocking field between the inner and outer fields even more clear.

It has also been discussed whether it would be possible to have a paved surface between the lanes, but this has been opted out for maintenance and cost reasons. Furthermore, a street-paved surface is not, in the formal sense, a lane line. It has also been discussed whether it would be permissible to have a different color on the asphalt between the lanes and according to the regulations it is allowed (there is nothing that says it is not allowed). However, the assessment is made that it should work just as well with a painted barrier field, preferably in combination with ribbing.

In order for the Hasselcirkeln to function, it is important that the driving lanes are controlled so that even long-distance drivers do not have to use the painted divider between the fields. In that aspect

therefore the same requirements are set regardless of a physical divider between the fields or just a painted divider, since the whole idea of the Hassel circle is that a vehicle should be able to stay in its lane. On the other hand, similar to today's roundabouts, one can imagine drive-over surfaces towards the center surface (roundabout surface) that long vehicles in the inner field can use.

If one would still like to have some form of physical divider between the inner and outer circulating lanes, an intermediate variant would be to place some barrier elements (or "concrete pigs") inside the barrier area/barrier, preferably in combination with road sign D2-3.

7.4. Type of "openings" between inner and outer fields in the circulation

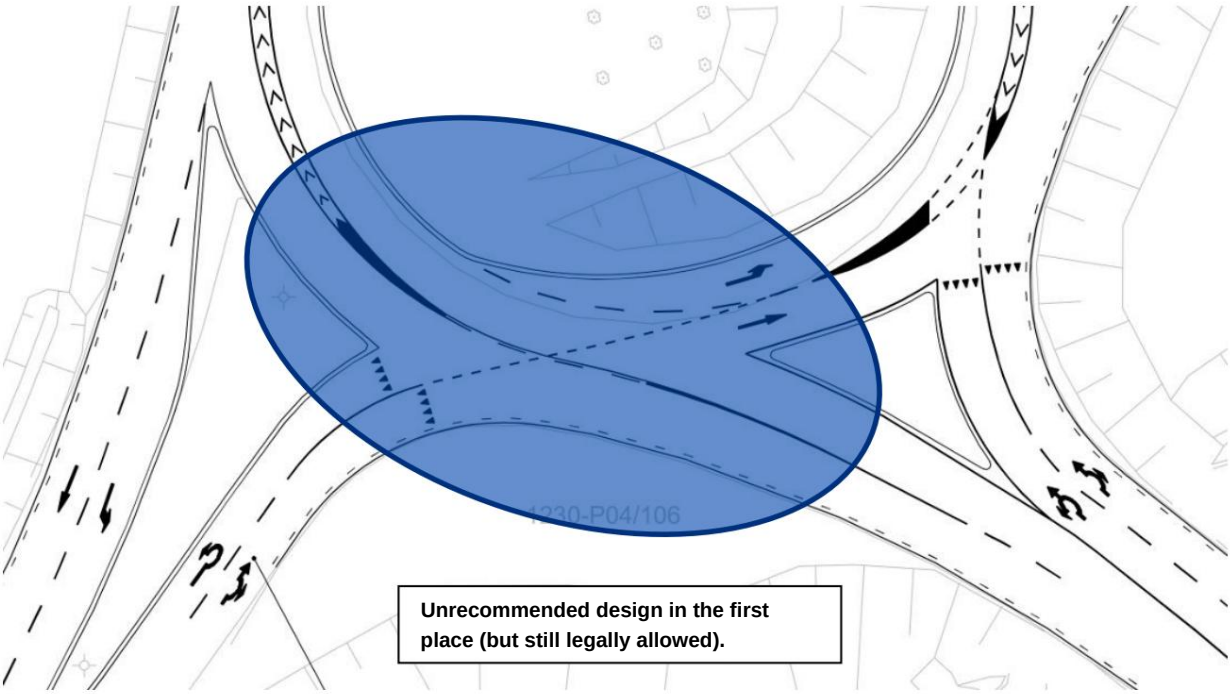
It is considered to be an advantage to have a double dashed line (formally an opening in the restricted field/restricted area) compared to only a single dashed line (lane line). The greater the distance between the dashed lines in width, the better. This is so that road users will understand that you should not change lanes here, which they should more likely understand with a double dashed line. If you have a shelter on the way out of the circulation between the lanes (like the Munkebäck road), it is considered even more unlikely that the drivers would change lanes at this opening when they are on their way out of the circulation, which is why a shelter in this place is recommended (which is also mentioned in later chapters).

If you only have a solid line between the inner and outer fields (and no blocking field which is most preferred) then it is still possible to have a double dashed line at the opening, as this can still be part of an opening in the blocking field/blocking area , given that you have a blocking field (preferably with a refug) after the opening. It is exactly the way you have it in Munkebäcksmotet (see picture below). However, also for the sake of the opening, it is considered best to also have a barrier field in front because the distance between the dashed lines can then be large even at its beginning.

Munkebäcksmote north-western part. Even though you only have a solid line (lane line) between the inner and outer fields (at the bottom of the picture), you can have a double dashed line for the opening, thanks to the fact that this is an opening in the barrier area towards the refuge. But if you have a barrier field/ barrier area instead of a solid line (at the bottom of the picture), the distance between the dashed lines could be large even at the beginning of the opening, which is considered an additional advantage, which is why it is recommended.

However, it should be pointed out that in addition to opening in the restricted lane/restricted area, only one lane line is also permitted at this location, according to what the traffic engineers have investigated. Partly, only a dashed lane line (M1) (which you usually have in circulation areas), but also M10 (Center line or lane line and solid line) is allowed. Having only one lane line (dashed line) is considered the least suitable. Alternatively, M10 (as the picture below shows), because then there is a ban on changing from the left to the right lane immediately before the exit. However, the solid line is at risk of being worn by traffic entering the circulation, so motorists traveling in the inner circulation lane
may still not see that it is a solid line, but interprets it as a normal dashed lane line (M1). If the solid line is still visible, there is also a risk that motorists from the connecting road may be led to believe that they are not allowed to cross it, which they must do to enter the inner circulating lane.

In summary, a wide "opening" (formally opening in a restricted area/restricted area) is therefore considered to be the best solution, because the width of the "opening" together with the subsequent refuge towards the exit means that motorists should understand to the greatest extent that they should not change lanes here. Then it even becomes a little clearer than it is in the Mun-kebäcksmotet, where you can see from real observations that the motorists understand how they shall drive. At the same time, motorists from the connecting road will also understand that they are allowed to cross here, because an "opening" in the barrier field/restricted area in this way is common in other places, for example closest to a central refuge where there is a connecting road and an "opening" in the restricted area/restricted area for them.



Alternative design with M10 (Center line or lane line and solid line) between the left and right lanes towards the exit. In this design, there is also no shelter between the fields on the way out. This design is considered to be generally OK according to the traffic engineers, even if it is not recommended in the first place. Instead, a barrier field/ barrier area inside the circulation, then an opening in the barrier field/ barrier area (double dashed line) and then a refuge between the fields towards the exit is assessed as a better solution. See section from CAD sketch with the proposed design in later chapters.

7.5. Type of separator between the lanes on the exit

In cases where you have two lanes on the way out of the circulation, a shelter is proposed, like you have in Munkebäcksmotet (see the picture below). Just like in other places where you have a shelter between two lanes in the same direction, it must also be provided with road sign D2-3, like the picture below. In order for the refuge to last well, granite edge supports are suggested instead of concrete edge supports. At this location out of circulation, both road users (and snow removal) are used to a refug (as this is common in GC passages), which is why the disadvantages of physical dividers that were mentioned in previous chapters for dividers between inner and outer circulation field is not considered to be here on the exit.

The purpose of this refug is above all to make it clearer for the road user leaving the circulation in which lane to drive, as well as to reduce the risk of vehicles changing lanes at the opening that is closest before this place. With a refug, the design is similar to the one found in Munkebäcksmotet (where the design has existed for many years and where no incorrect driving behavior has been noted, not even in snow).

Refuge on the way out, with road sign D2-3.

7.6. Minimum lane width

Each lane must have the width required so that the lanes for lorries are also fulfilled (with the exception of, for example, if the overpassable surface is used towards the middle surface for traffic in the inner lane). Furthermore, there must be at least 4.5 meters between fixed obstacles, a distance which, however, is still met in most cases because the driving lanes often require even wider, considering the needs of the long vehicles in curves.

7.7. No obstacle as a rule in having a sudden/cross angle change

According to the traffic engineers, there is no obstacle based on the regulations to have a sudden/ cross-angle change of the inner edge where the new inner lane starts to grow out. As has also been mentioned in previous chapters, vehicles that have to make a U-turn do not have to follow the angle change of the inner edge, but can smoothly turn into the new inner field on the route offered. This means that as long as you make this distance long enough, it is judged that there are no obstacles to this angle change. Even oval circulation places have a changed radius inside the circulation, a design that is accepted.

7.8. What would happen if the lines in the Hassel circle were to wear out?

A question that has been discussed concerns what would happen if the lines in the Hassel circle were worn out, partly based on how road users would drive and partly based on legal aspects. Just as for other roundabouts, especially those that also have lanes that only lead to exits, it should be important to maintain the line painting so that the lines do not become too worn out. Circulation places that have one or more lanes that only lead towards the exit, we have an estimated several hundred of them in Sweden, which is why Hasselcirceln from that aspect would not be alone. As has also been mentioned in previous chapters, neither in these roundabouts nor in the Hassel circle in the outer lane can you continue the lap around the roundabout surface if the lane you are traveling in only leads towards the exit. Both from practical driving and from legal aspects in general, it already works today in this type of roundabouts, so the conclusion is that it should work at least as well in
The hazel circle. The design in the northwestern part of the Munkebäck Smote, which has also been mentioned in previous chapters and which in some parts resembles a Hassel circle, has also existed for many years and works well in practice.

If you compare with other roundabouts in general, the lines in Hasselcirceln should also wear more slowly, given that road users are more controlled in their lane.
For example, the barrier field/barrier area between inner and outer fields is not expected to wear so quickly. The connecting traffic that must pass through the opening in the barrier lane/barrier area between inner and outer fields will probably also travel in the same rut to a relatively large extent, which is why probably all the line painting would not wear out so quickly here either.

As has also been mentioned in previous chapters, one must also bear in mind that the importance of a line is at least as important in other places in our road network, where at first glance one might also think that there could be a theoretical risk of misunderstandings and legal complications if the line would not be visible for various reasons, but where in reality it still works well enough that the solution is accepted. This applies, for example, to 2+1 roads where you have a continuous lane closest to the center guardrail and where an on-ramp exits and becomes K1. Often the access lane is connected with a relatively tight curve, while it is usually only a solid line that separates the lanes. Here, the risks of serious accidents would also be significantly greater than in a roundabout in the event of a misunderstanding, given the significantly higher speeds.

8. Would passing GC road users be affected?

If you compare it with today's roundabouts, a conversion to the Hassel circle is judged not to entail any disadvantages for unprotected road users who pass on the GC passages at the entrances and exits. The shelter proposed for the Hasselcirkeln at the exits can also be advantageously used to have a GC passage, as is often the case today. Similarly, there is nothing to prevent you from having a refuge between the lanes at the entrances, even in a Hassel circle, as you often have today at GC passages.

One can even imagine certain advantages for GC road users with a Hassel circle. If a GC road user about to cross one of the exits today looks towards the circulation and sees an arriving vehicle, it may be difficult for the GC road user to know in which of the lanes on the way out of the circulation that the car will use. With a Hassel circle, this becomes clearer.

Furthermore, in the closely related Turbo roundabout in the Netherlands, the speed of the drivers has been seen to decrease slightly inside the roundabout, compared to the corresponding roundabout before the rebuild. If this were also to become a fact for the Hasselcirceln, which does not seem improbable, it could also be seen as an advantage for GC road users. The slightly reduced speed can also make it easier for vehicles entering the circulation to find a sufficient time slot, which also contributes to

accessibility increases.

Example of a multi-lane roundabout with two lanes towards the exit. Here it can be perceived as unclear for a passing GC road user in which of the lanes that an arriving car from within the circulation will use. With a Hassel circle, this would become clearer for GC road users, which can be seen as an advantage for them.

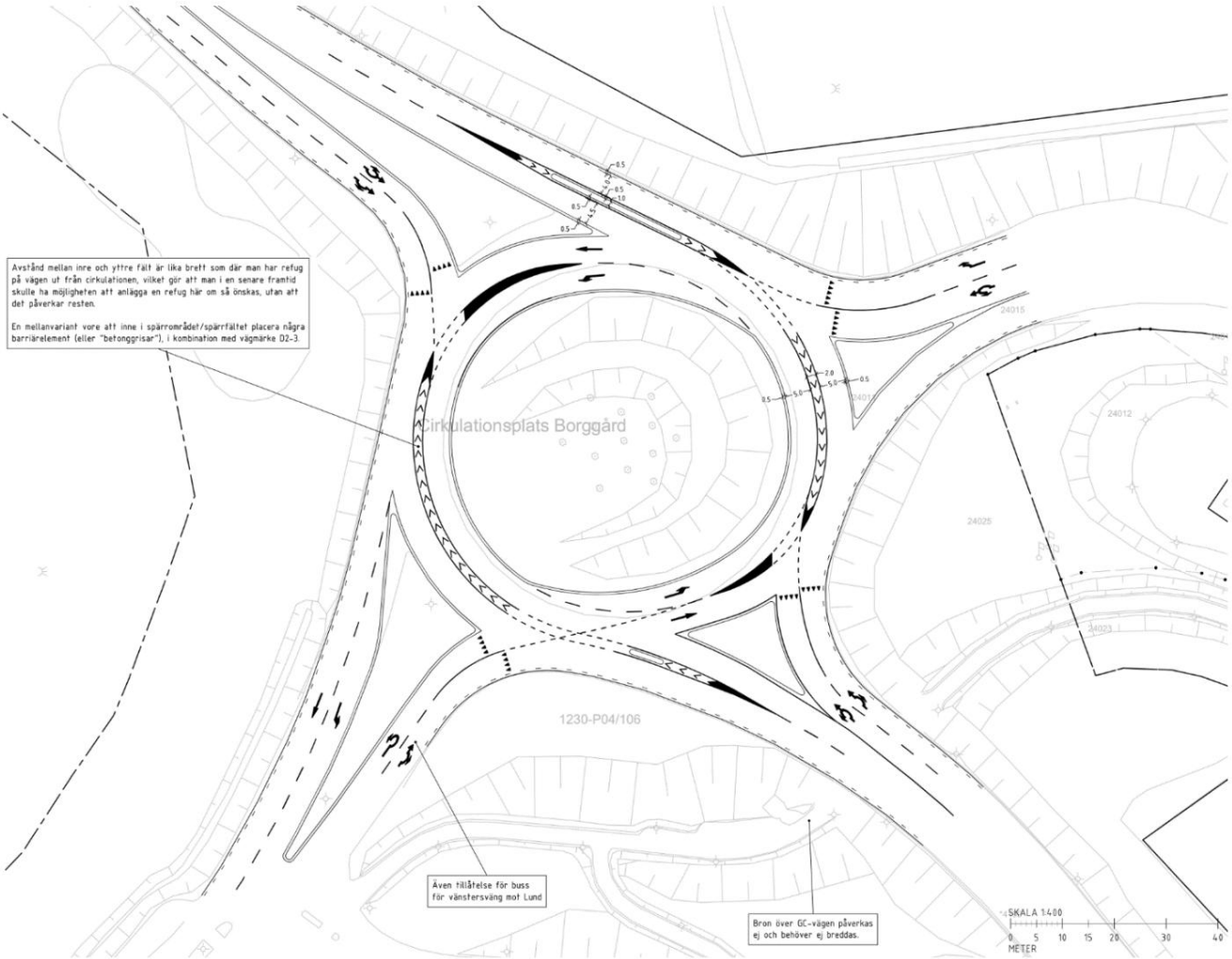
9. Possible design of the Hassel circle

Based on the aspects and proposed solutions discussed in different chapters of this PM have some simpler CAD sketches have been produced for truly conceivable locations. Even if a unique design would be needed for each specific location (both based on geometry and based on the need for the number of lanes in different relationships), these sketches can still be seen as good examples of how a Hassel circle can be designed, based on its characteristics. See also the sketches in the Summary at the beginning.

Among other things, the CAD sketches have a wide barrier field/barrier area between the inner and outer circulating fields, but with a refuge between the fields on the way out. They have a sudden/cross-angle change where the new inner lane starts to grow out (this is one of the most important features of a Hassel circle, so that the road user understands that they must still stay in their lane and not continue along the inner edge). However, it is not judged that the radius required to make a U-turn will be too narrow. Furthermore, the "openings" are judged to be well designed, both so that road users from the connecting road will understand how to drive, and so that it will not be tempting for a road user who is already inside the circulation to change lanes here. Compared to today's multi-lane roundabout, the assessment is that both the number of conflict points decreases, and that the capacity increases (number of vehicles that can pass the roundabout during a certain time).

So please note that the selected lane divisions on the CAD sketches below (i.e. number of lanes and from which lanes into the circulation from which you can turn right, left and straight ahead) are produced based on what is deemed most suitable for the specific locations. Despite this, you can see that the characteristics of what a Hassel circle consists of are the same in all of them and where the different sketches together therefore provide good examples/inspiration of how a Hassel circle can be designed based on different specific conditions.

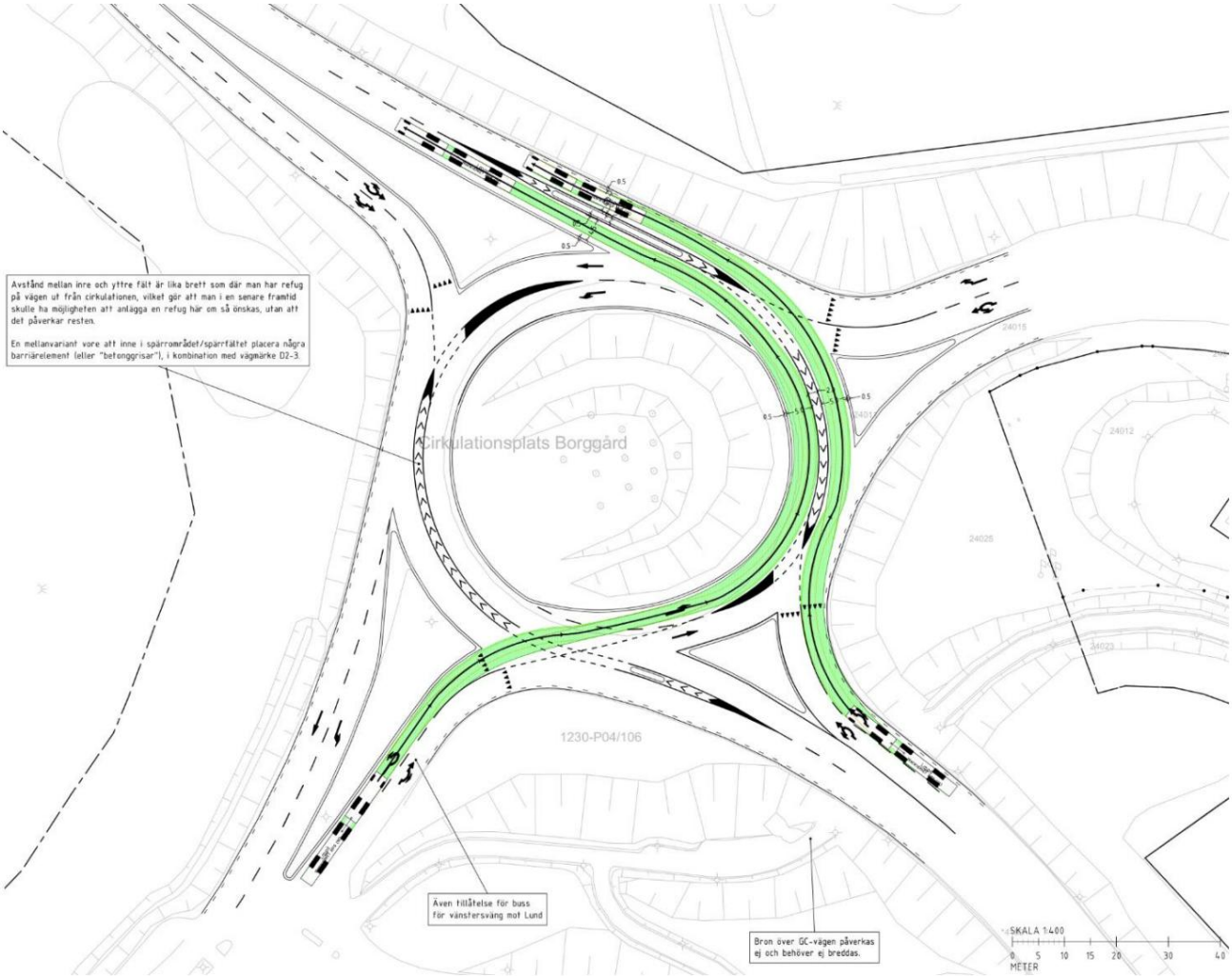
9.1. CAD sketch 1



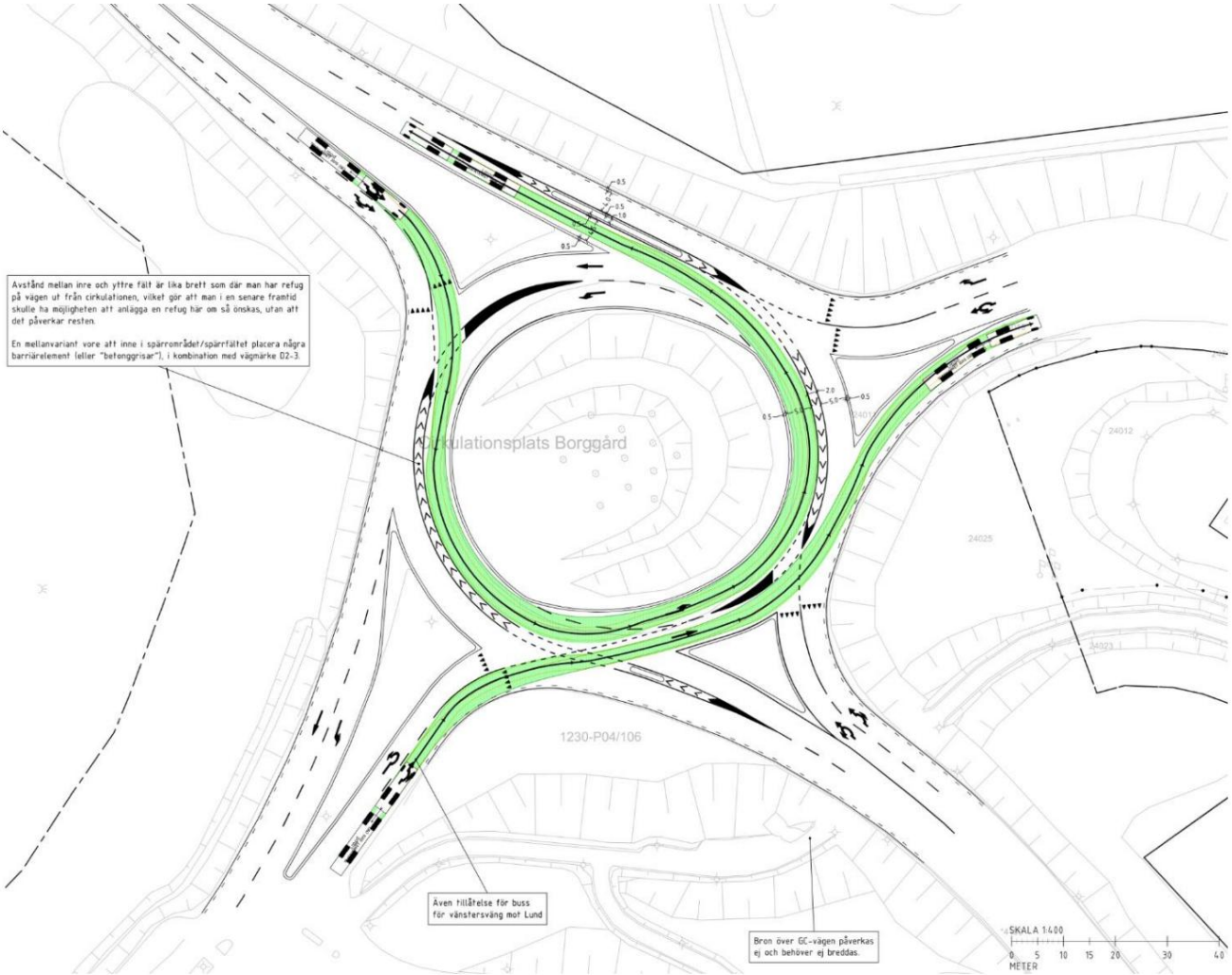
Simpler CAD sketch for the Hassel circle, drawn for a specific location, but where the sketch can still be used to generally see what the design could look like. It has been checked with lane markings that even lorries can stay within their lane. This is for all relationships, even for U-turning traffic turning into the new inner lane.

In this example, there are double through lanes straight ahead in both directions between northwest and southeast. When approaching the roundabout from the south-west, straight ahead and right in the right-hand lane are signposted, while from the east only right turns are allowed in the right-hand lane.

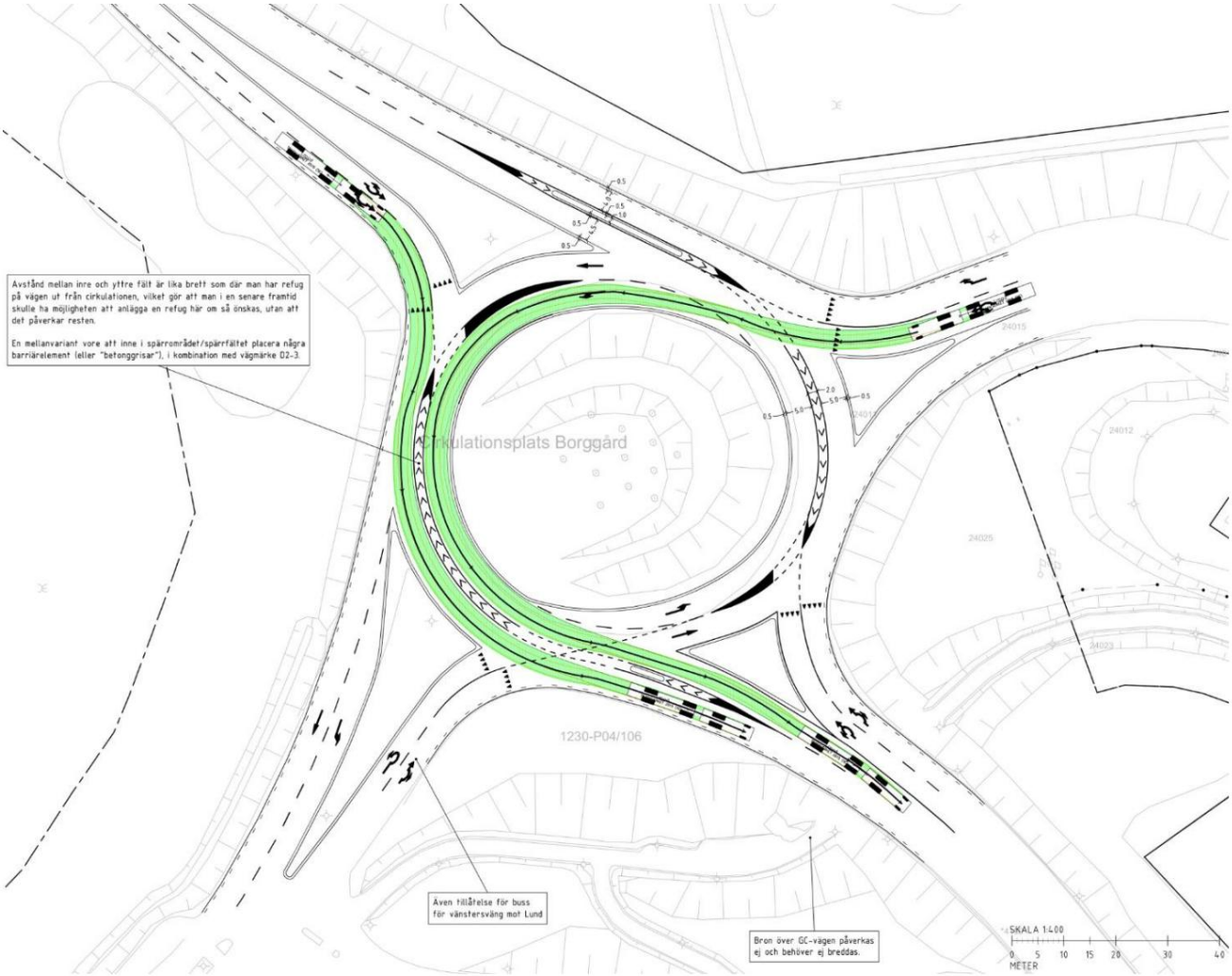
Even if only a barrier field/barrier area between the inner and outer circulating fields inside the circulation is recommended (as stated in previous chapters), the barrier field/barrier area is still wide enough to later be able to set up a refuge. An intermediate variant would be to place some barrier elements (or "concrete pigs") inside the barrier area/barrier field, preferably in combination with road sign D2-3.



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).

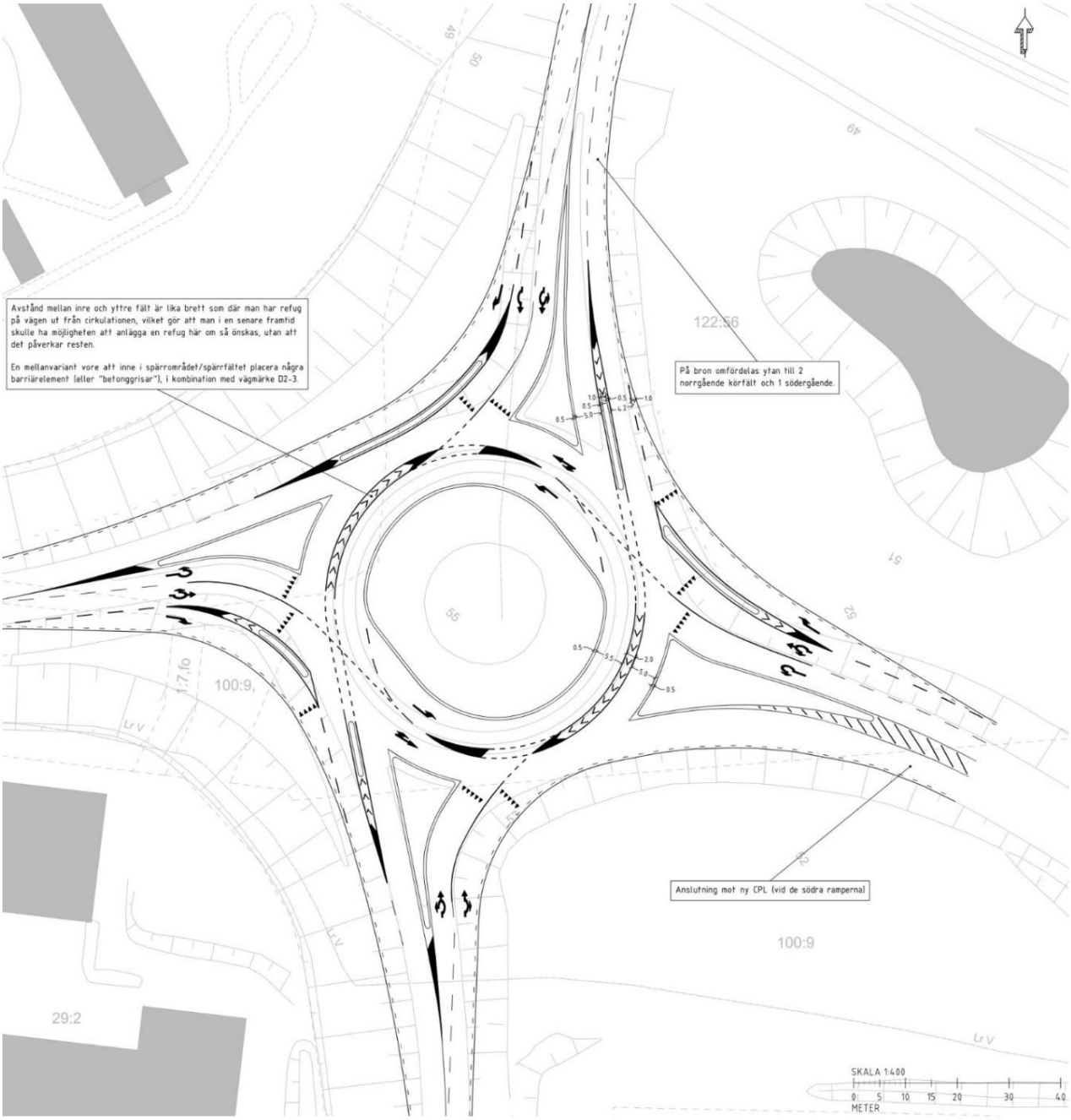


Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).



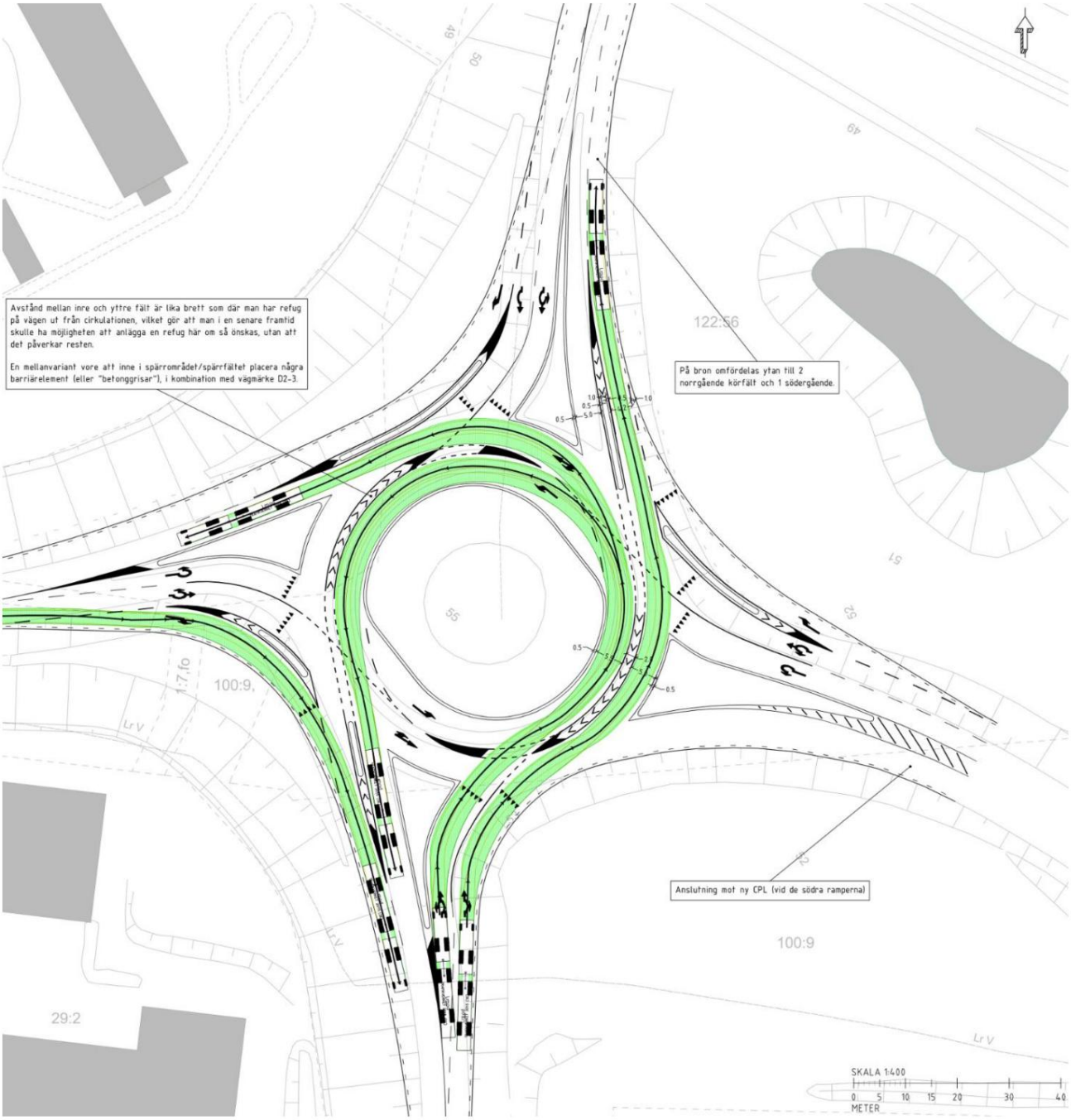
Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).

9.2. CAD sketch 2

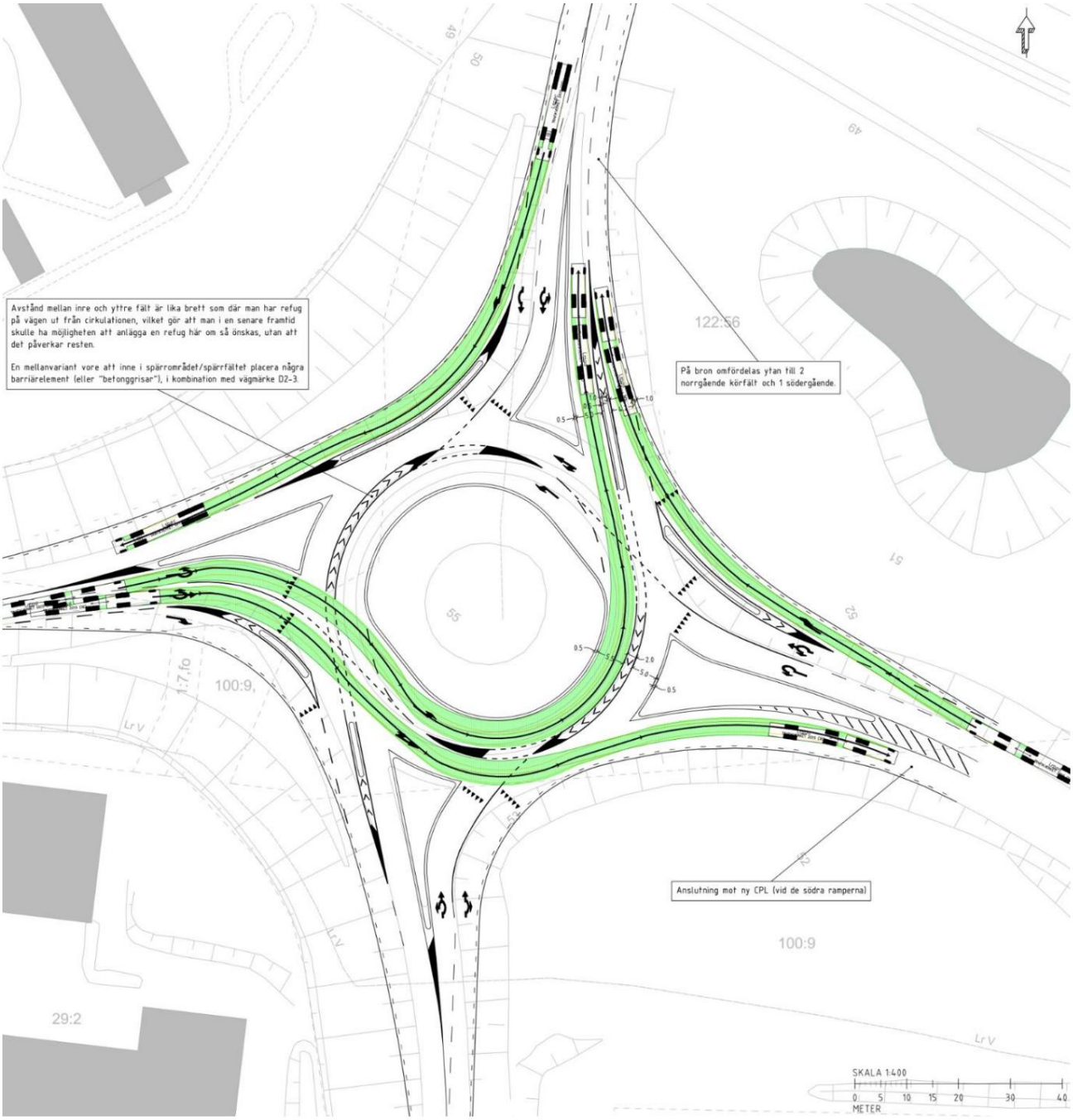


Simpler CAD sketch for the Hassel circle, drawn for a specific location, but where the sketch can still be used to generally see what the design could look like. It has been checked with lane markings that even lorries can stay within their lane. This applies to all relationships, even for U-turning traffic turning into the new inner lane.

In this example, there are double through lanes in both directions between south and north. When approaching the roundabout both from the east and the west, both lanes can be used for left turns, and that there is a separate lane for right turns. Even from the north there is a separate field for right turns, in this case in the form of a free right.

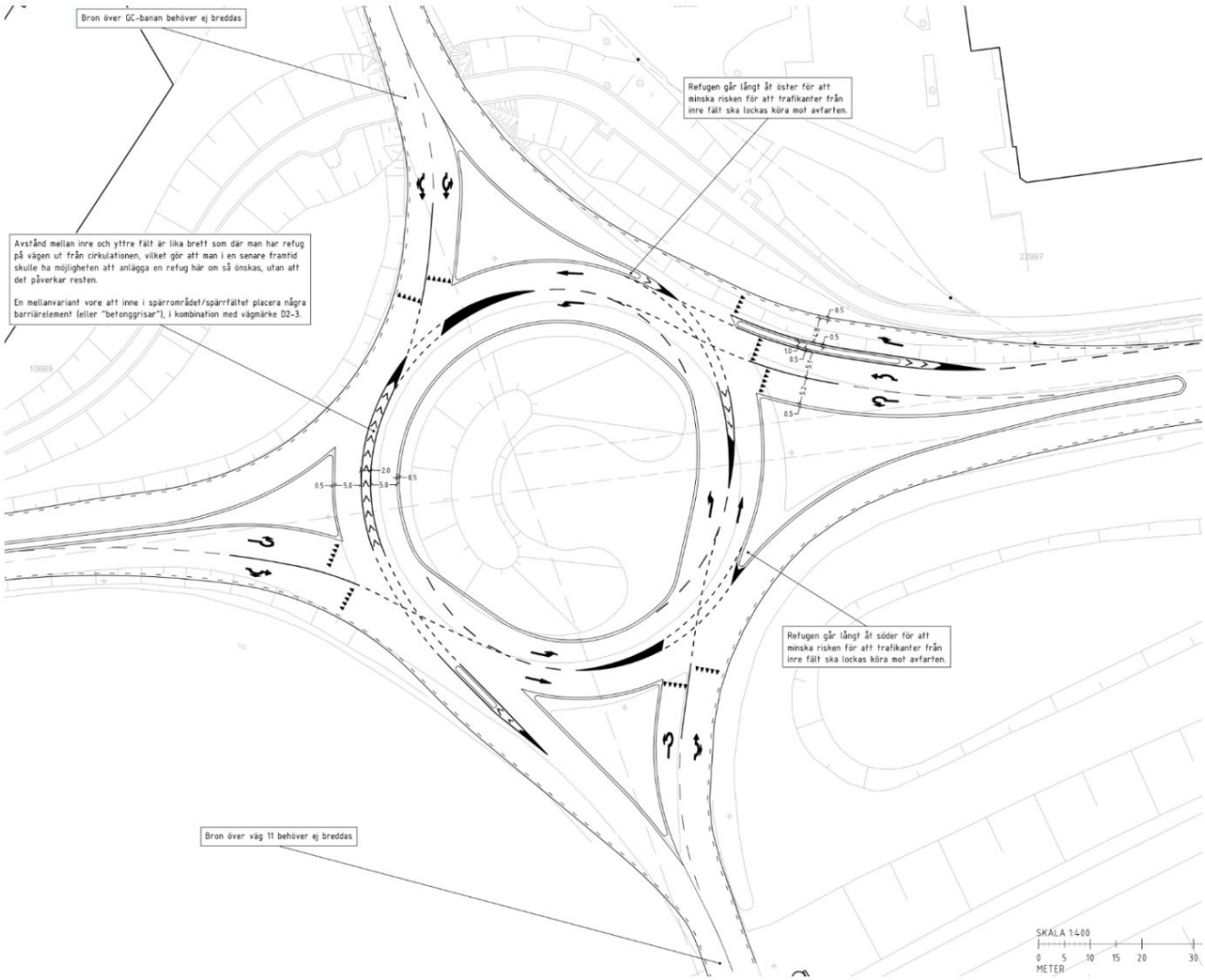


Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).

9.3. CAD sketch 3

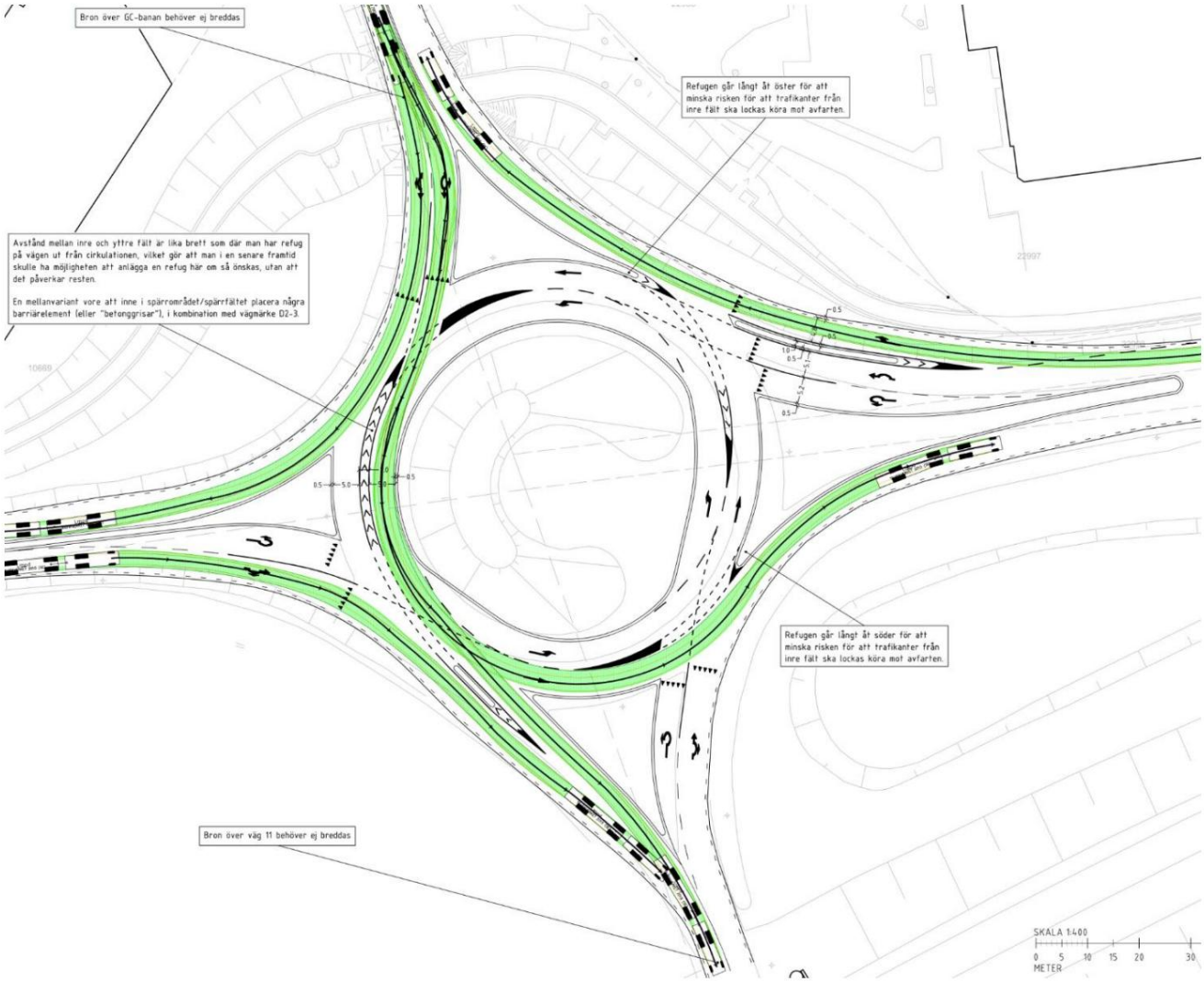


Simpler CAD sketch for the Hassel circle, drawn for a specific location, but where the sketch can still be used to generally see what the design could look like. It has been checked with lane markings that even lorries can stay within their lane. This is for all relationships, even for U-turning traffic turning into the new inner lane.

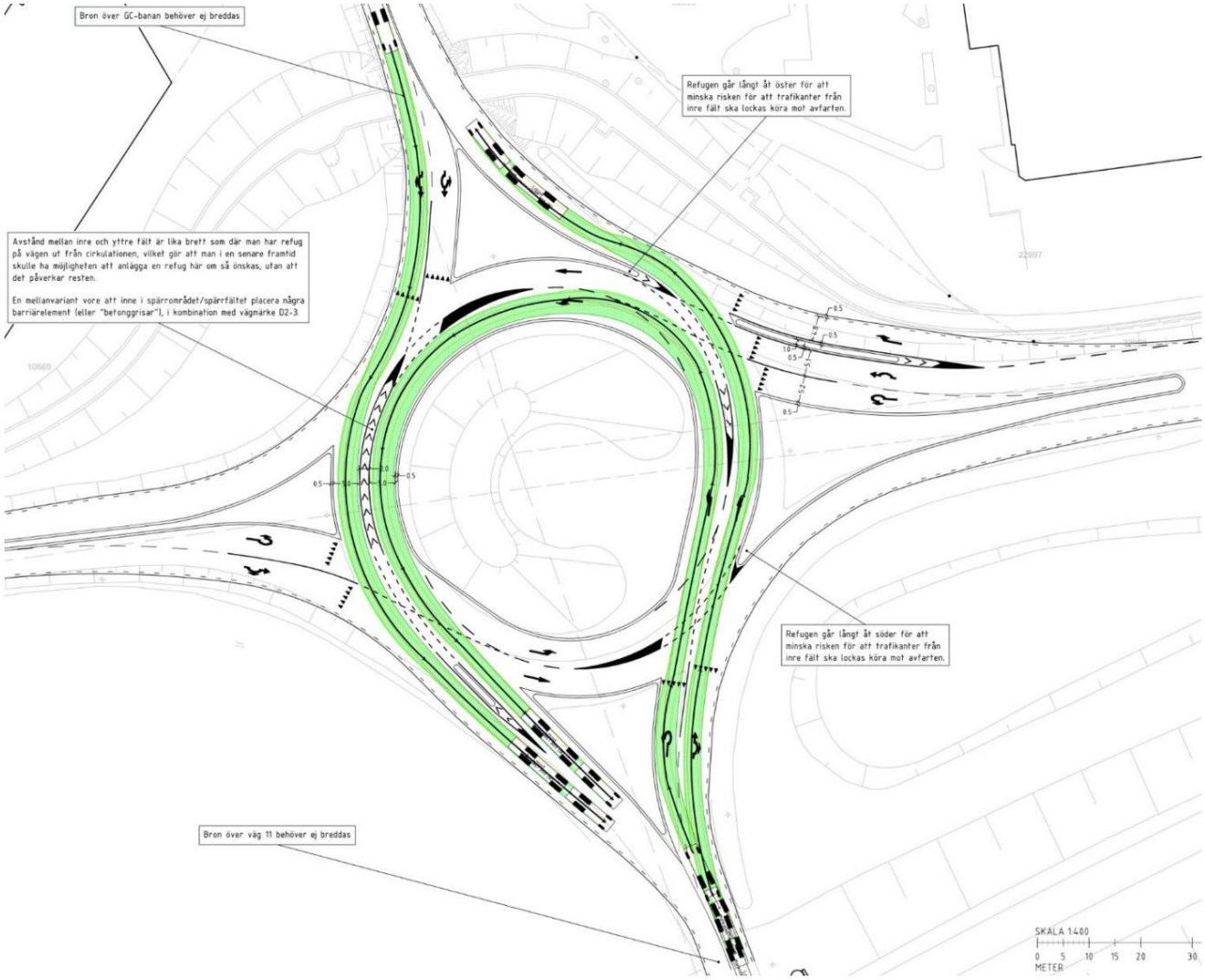
In this example, there are only double lanes straight ahead from one of the entrances to the circulation instead of two, in this case from the north. This means that this circulation is designed a little differently, among other things in the form that there are three sudden/tight angle changes where the new inner lane grows out instead of two as in the others.

If you have a roundabout with only exits with one (1) lane, the Hassel circle can still be useful. Then the entire circulation would be like the eastern half of the sketch above, with thus a total of four sudden angle changes (no. 1 on the sketch above) and no places at all where there is a barrier/restriction area between the lanes on long stretches (no. 2 on the sketch above). However, you get the most benefit from the Hassel circle if you have two lanes facing one or two of the exits. In many cases, you can also create it relatively easily, as you can let the lanes merge with each other after about 60 – 80 meters after

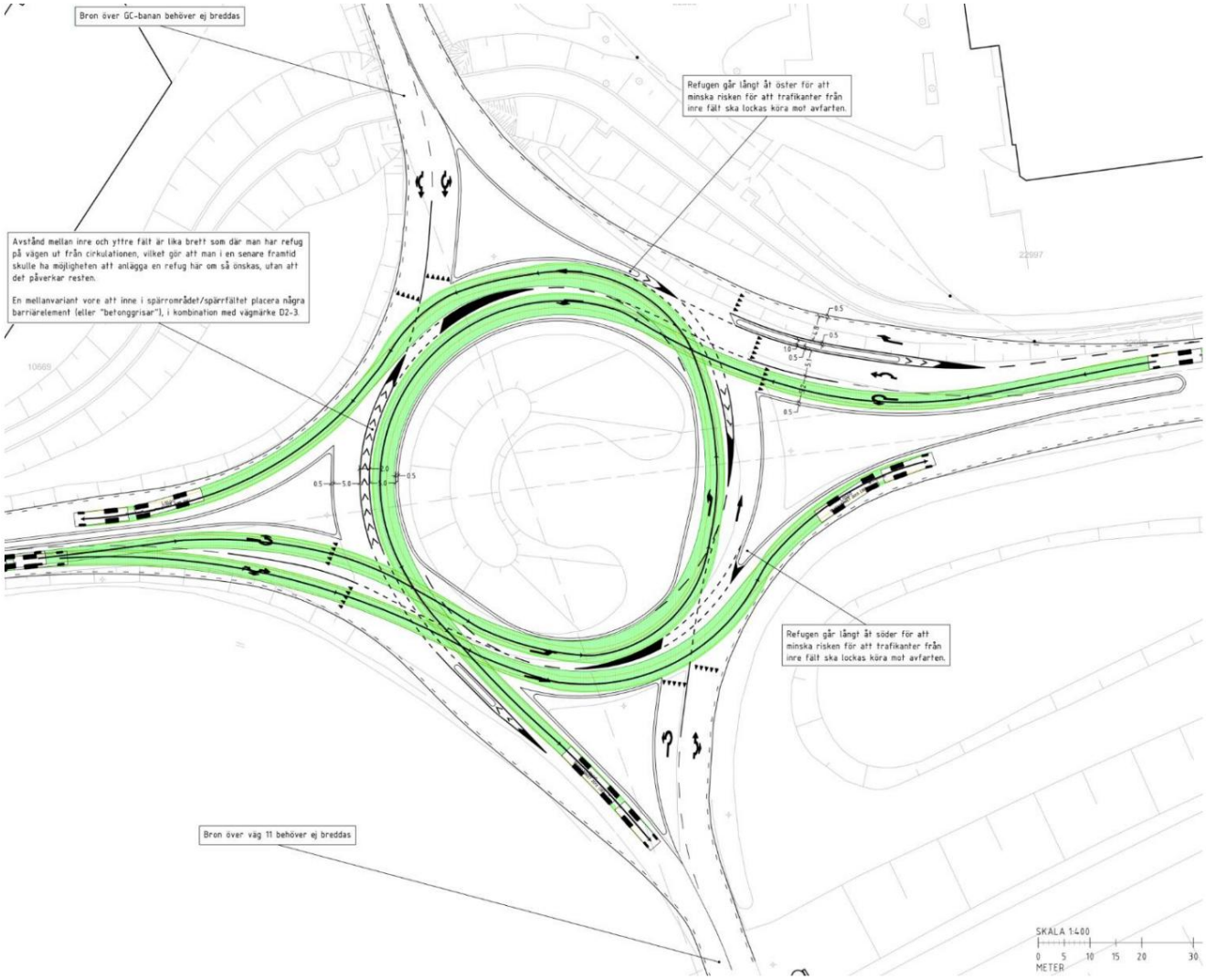
that you have left the circulation (road sign E15, interweaving). See, for example, the sketch above regarding how it is drawn on the exit to the south (in this specific case, there is a bridge in the farthest south which limits how far you can have two lanes).



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).

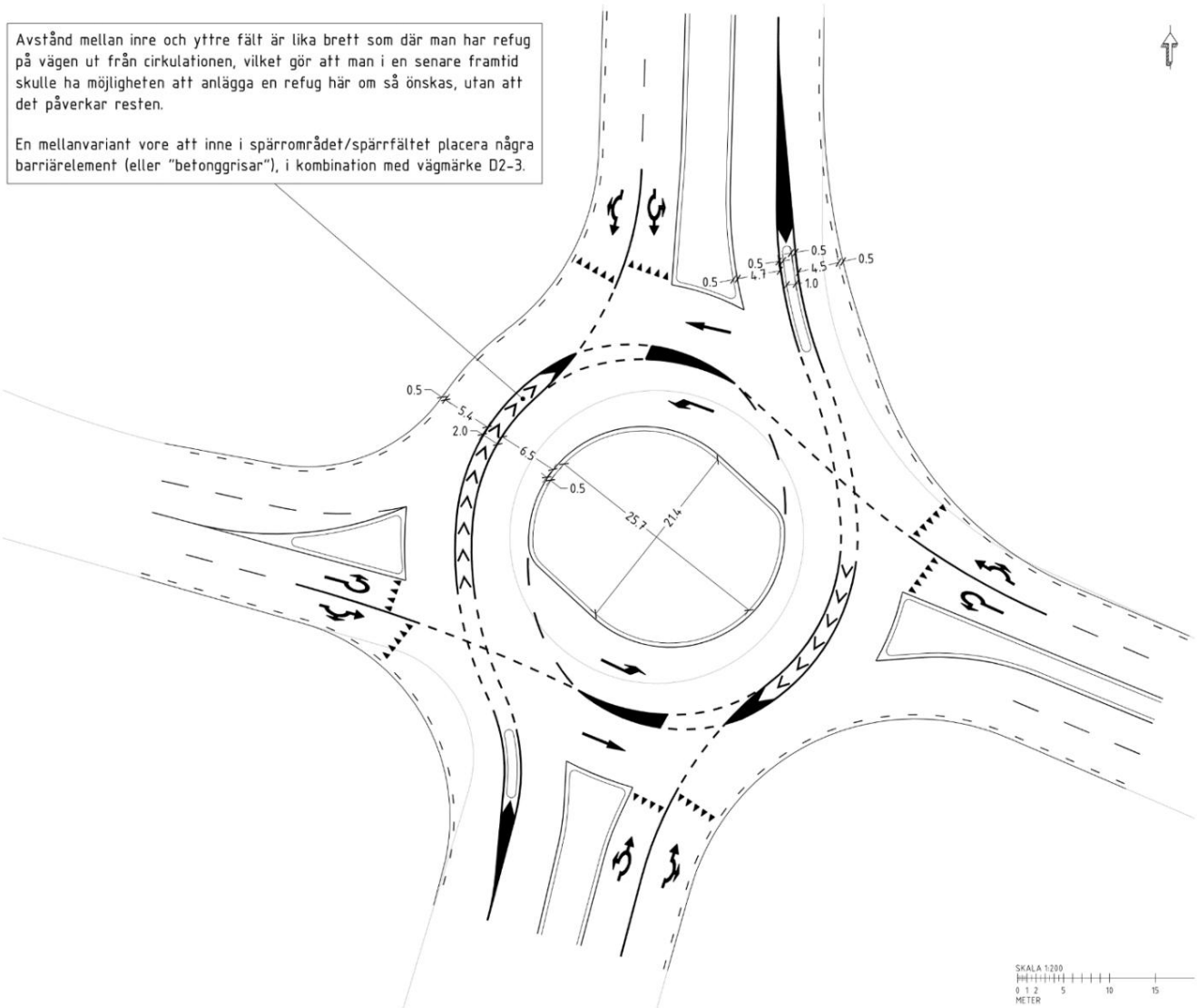


Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).

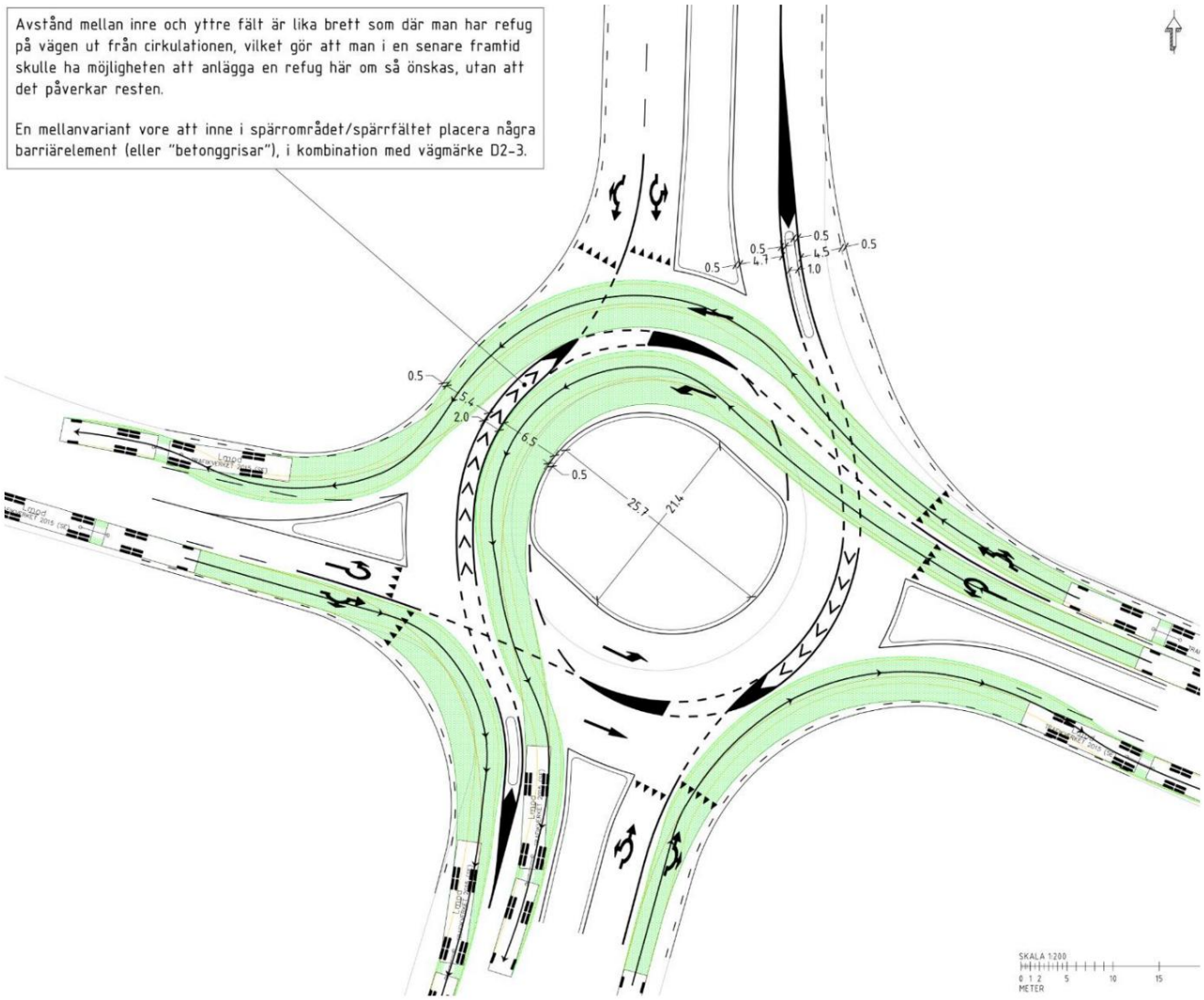
9.4. CAD sketch 4



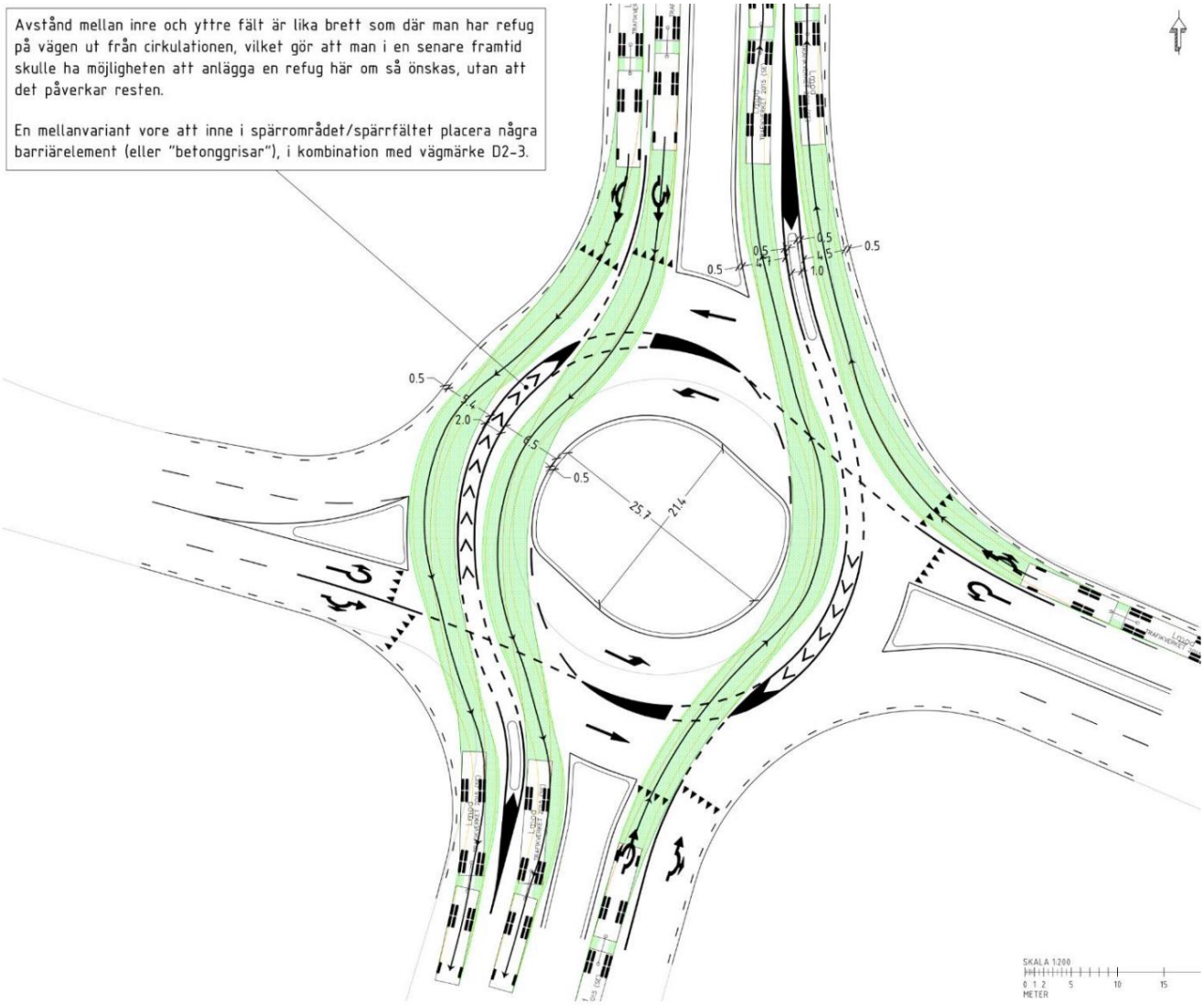
Simpler CAD sketch for the Hassel circle, drawn for a specific location, but where the sketch can still be used to generally see what the design could look like. It has been checked with lane markings that even lorries can stay within their lane. This is for all relationships, even for U-turning traffic turning into the new inner lane.

In this example, the circulation is smaller, with an inner diameter of about 30 meters with today's design (inner radius about 15 meters), but in connection with the conversion to the Hassel circle, some area towards the center would be used. This is in order to make it possible even for long vehicle crews to stay within their lane (even during U-turns).

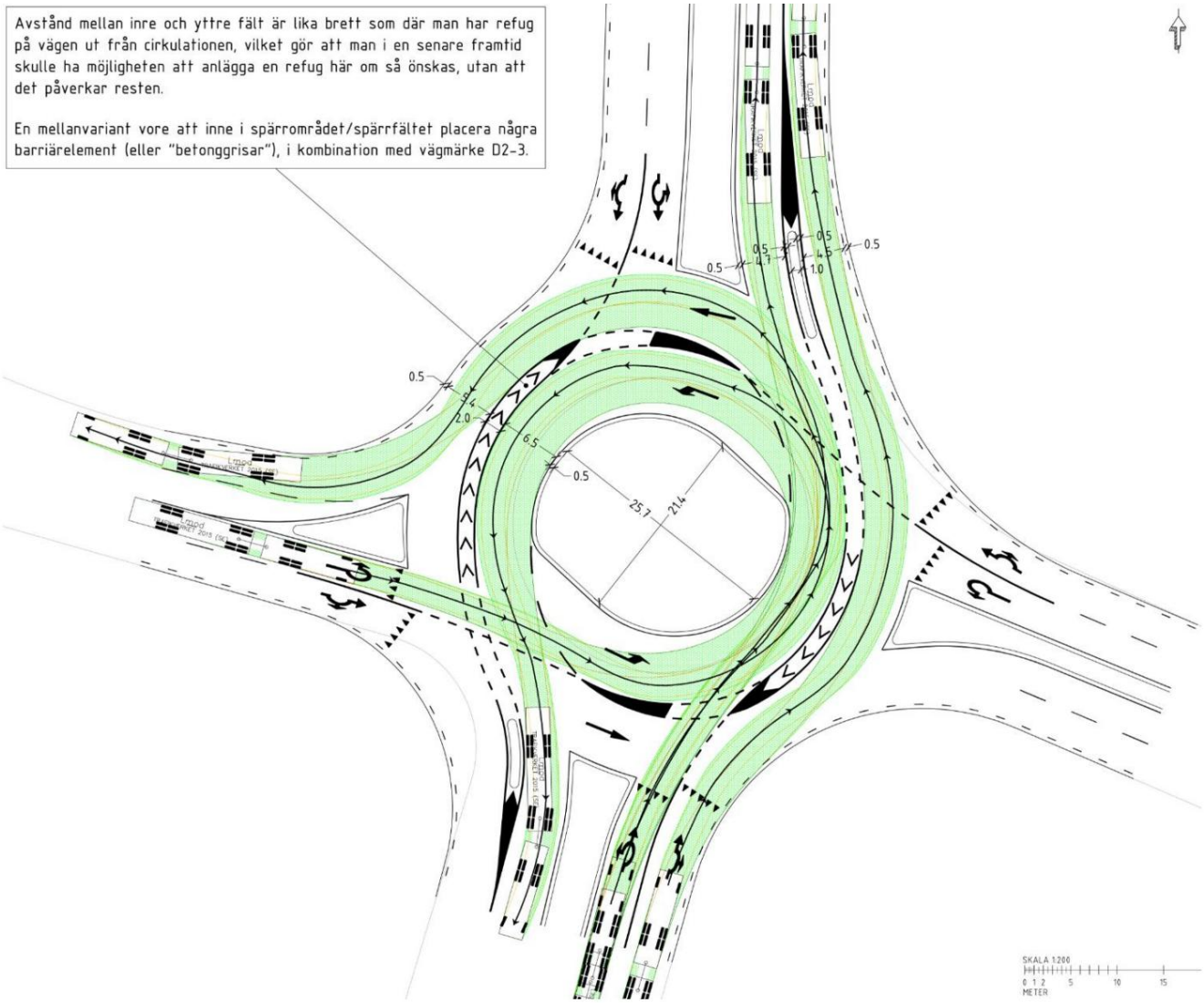
In this example, there are double through lanes straight ahead in both directions between north and south. When approaching the roundabout from the west and east, signs are straight ahead and right in the right lane and left turn in the left. This type of lane division and size of circulation space is very common.



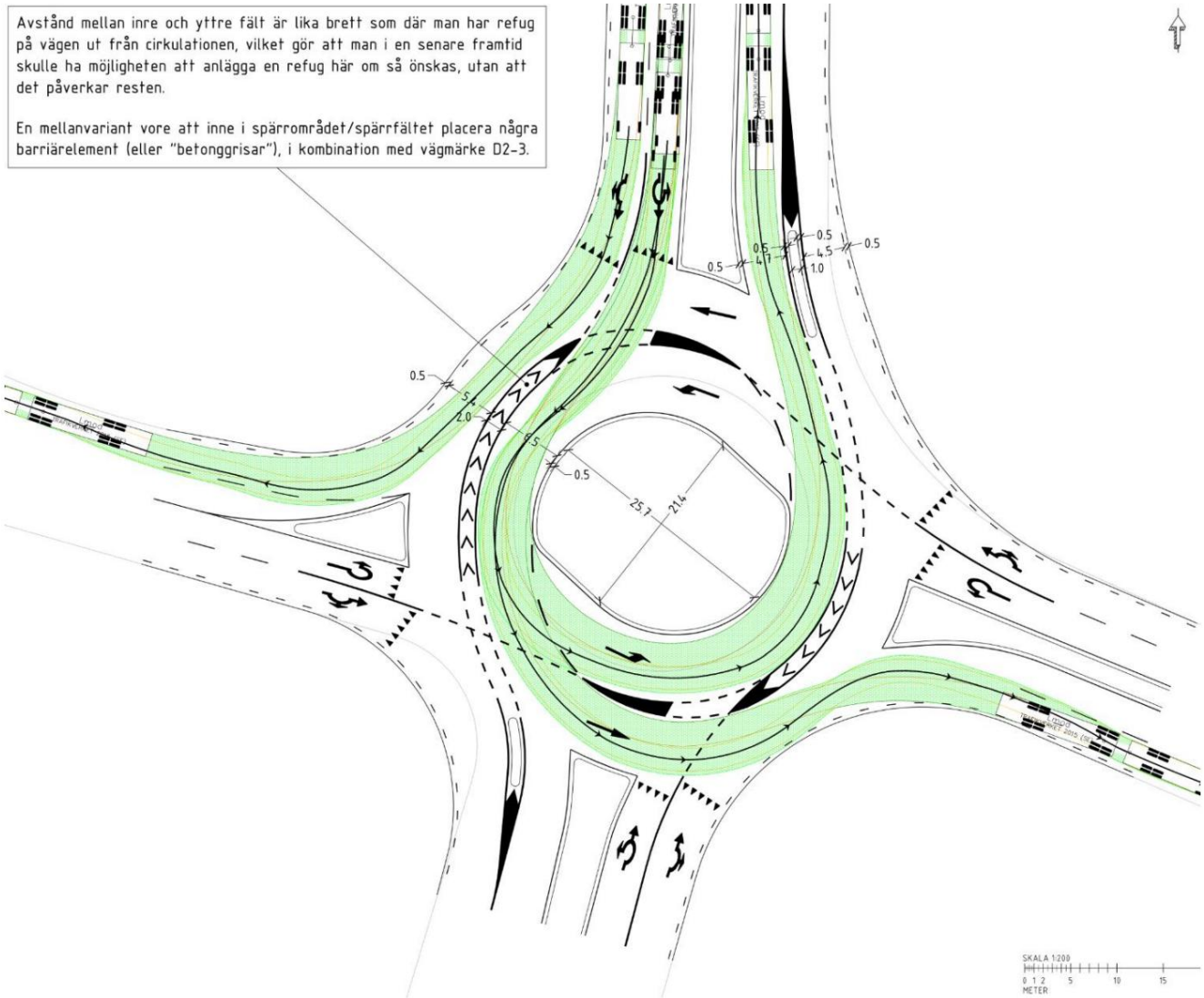
Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).



Simpler CAD sketch for the Hassel circle, with tracks that have been checked (note that the tracks always have a little extra margin and therefore look a little "wider" than in reality).

10. Conclusion

Based on the aspects that are highlighted in this PM, partly the shortcomings that are deemed to exist in today's multi-lane roundabouts, to which potential Hasselcirceln is deemed to have (both on the basis of a reduced number of conflict points and on the basis of assumed increased capacity), then Hasselcirkeln is deemed to have a good opportunity to be able to add a benefit.

Here we can mention the capacity increase of **about 22%** that a VISSIM model with general flows calculated for the Hassel circle, as well as the reduction of incidents by **about 72%** that studies of the closely related Turbo roundabouts in the Netherlands have shown. In both cases in comparison with the corresponding circulation space with today's design. It should be emphasized, however, that it is only after construction with the associated pre- and post-measurements that one can comment on what benefits can conceivably arise
for each specific location.

An increased capacity means the possibility of better accessibility, which can benefit several types of vehicles, including car, bus and truck traffic. It is therefore not just about improving car traffic, but rather for all types of traffic. In an overloaded circulation area, a conversion to Hasselcirceln can also potentially be an alternative to a more expensive measure, such as, for example, a plan-free traffic area.

The idea is to create a basic solution based on the four-step principle that provides great benefits in a cost- and surface-efficient manner.

Furthermore, it is not considered to entail any disadvantages for unprotected road users who pass on GC passages at the entrances and exits with a Hassel circle, but one can even imagine that the situation for them would improve somewhat.

During the deeper discussions held between different competences within the Swedish Transport Administration and WSP, several different aspects have been raised (among others maintenance and law) and where a more precise idea about possible design has been developed.

Thanks to the comparisons that have been made with other locations, including the northwestern part of the Munkebäcksmotet which resembles a Hassel circle, one can also feel more confident that the solution will work and be understood by road users.

2022-04-14

WSP Sweden AB

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