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Article

Important properties of central island and median island at roundabouts

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Abstract: The central island and median island are very important elements of a roundabout, which strongly influence the impact on traffic and safety of road users. The central island should be designed in such a way that it is perceived as an obstacle in the approach. At roundabouts with an outside diameter of more than 35.0 m, the central island should prevent the view from the approach road straight ahead to the opposite exit. This can be achieved with various design options such as trees in the central island. The layout of the central island should be customized to suit the particular local conditions. When designing the central island, it is important to factor in the requirements of buses, along with municipal and emergency vehicles. While aesthetics is a consideration, the geometric design of the intersection is a critical aspect in roundabout planning. If sufficient space is available after considering the turning radii of key vehicles, curbs can be used to define boundaries. Alternatively, paved island sections that allow partial or full traversal can be a viable option.

Keywords: central island; diameter; median island; roundabout; safety; traffic

1. Introduction

At roundabouts, vehicles travel more slowly than at other intersections with priority for one road. The design of a roundabout is primarily determined by traffic geometry in the intersection area, in addition to aesthetic considerations. When planning such facilities, the needs of public buses as well as municipal and emergency vehicles must be taken into account. If, after considering the turning paths of design vehicles, a sufficient remaining area is available, curbs may be used to create a boundary. Alternatively, island areas can be paved and made partially or fully traversable. The design of the central island should be adapted to the specific location. The central island (roundabout island) is the center of the roundabout, around which vehicles circulate. It serves to deflect entering vehicles and must be clearly prominent within the roundabout. Additionally, sightlines should be blocked using structural and design measures for safety. The central island is designed to be traversable by large vehicles only in mini-roundabouts.

The median traffic island separates the entry and exit lanes of an intersection arm. It is used to guide traffic, provide a location for traffic signs, and, if necessary, offer a crossing aid for pedestrians and cyclists. Generally, median islands are only designed to be fully or partially traversable in mini-roundabouts. Structural median islands should always be installed between the entry and exit lanes. They enhance the visibility of the roundabout and help channel or separate individual traffic flows. When pedestrians are crossing, the island should ideally be 2.0 m wide (and at least 2.5 m wide for cyclists) at the pedestrian crossing. The median islands between the entry and exit lanes should also serve as crossing aids for pedestrians. The crossing point should be set back by 5.0 m from the edge of the roundabout's circulating lane, allowing waiting vehicles to queue before the pedestrian crossing and outside the roundabout. In exceptional cases, markings (hatched areas) may be used instead of structural median islands, such as when space is limited or at less significant roundabout approaches, provided there are no pedestrian crossings.

2. Methodology

This study focuses on the center island and lane divider of a roundabout. First, the roundabouts were analyzed in terms of traffic, safety and stress. Subsequently, all elements of a roundabout were presented and defined. Some empirical models for predicting the gap acceptance parameters based on the geometric and functional parameters of different roundabouts were also briefly presented by selected authors. Finally, the project design principles from Austria and Germany, including the construction methods of center islands and lane dividers with some examples of Upper Austrian roundabouts, were explained.

3. Traffic safety and efficiency of roundabouts

3.1. Traffic safety of roundabouts

The main advantage of roundabouts over conventional traffic junctions is the higher level of traffic safety. This results from the consistently lower through traffic speed, the improved visibility and the reduced number of conflict points. This also reduces accident cost rates, as accidents generally have less serious consequences. **Figure 1** shows the traffic flows and conflict points at different types of junctions. A conventional junction without traffic lights has a total of 32 conflict points. Traffic light control can reduce the number of conflict points to 16, but this incurs additional costs. If there is sufficient space, the number of conflict points can be reduced to 8 or 4 with additional turning lanes and appropriate traffic light control [1].

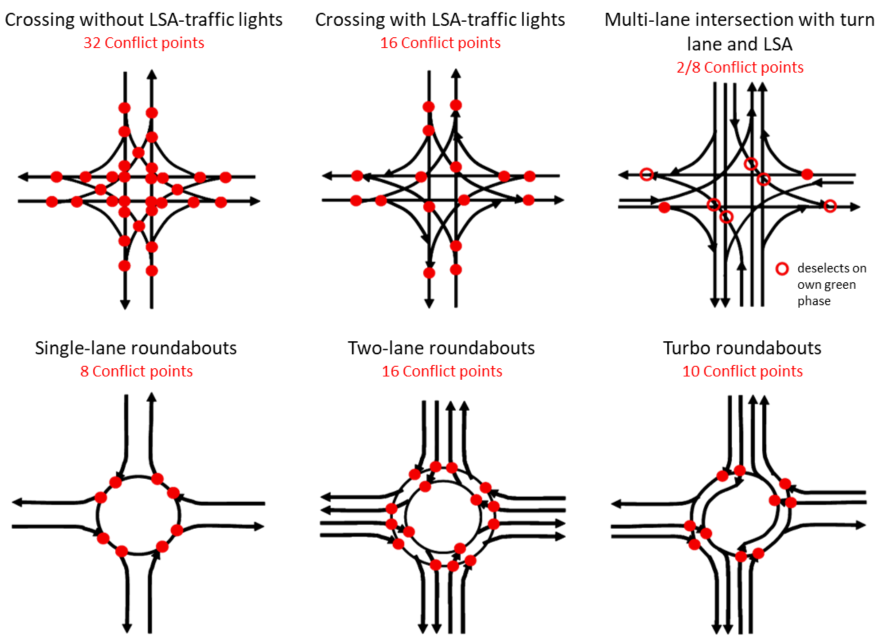

Figure 1. Safety aspects of intersections—conflict points by intersection type [2] (edited by author).

At single-lane roundabouts, on the other hand, there are only 8 conflict points, which are also easy for the driver to detect due to the geometric conditions. At the more efficient two-lane roundabouts, on the other hand, the number of conflict points doubles to 16, which again slightly increases the accident rates compared to the single roundabout. In addition, the practical capacity of the inner lane is only about 25%–35% of the outer lane [2]. The safety aspects of junctions—conflict points and through-traffic speed—are shown in **Figure 2**.

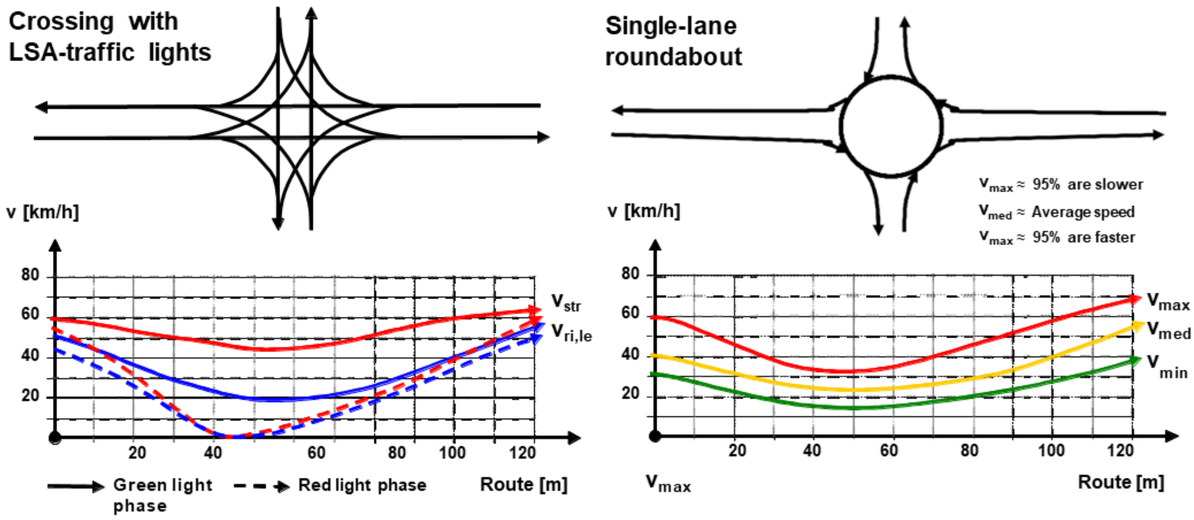

Figure 2. Safety aspects of intersections—conflict points and transit speed [1] (edited by author).

3.2. Efficiency of the roundabouts

The significant traffic load for the capacity of the roundabout (KVP) can be determined either by traffic counting and conversion into passenger car units [PKW-E] according to FSV [3] **Table 1** or from the DTV trend map 2005 [4] for the forecast horizon (+15 ... 25 years) [PKW-E/24h]. The relevant hourly value MSV [PKW-E/h] can be calculated by multiplying the DTV [PKW-E/24h] by the k-factor of 0.1 ... 0.2 depending on the type of load or from the analysis of the determined traffic corridors. The hourly value MSV of the relevant traffic load for the design is thus between 10%–20% of the annual average daily traffic load JDTV. With the same load on all entrances and exits (Qex = Qax) to the roundabout as shown in **Figure 3**, the maximum capacity of the access road Qe is 600 cars per hour (Ø 26 m) to a maximum of 800 cars per hour (Ø 40 m). Assuming an average works traffic per lane (k = 0.10–0.12), these results, for example, in a maximum application range of 2 × 800/0.10 = 16,000 for the single-lane roundabout for the intersection of 2 roads with 16,000 vehicles per day each [2].

Table 1. Dependence between the outer diameter DA and the structural width of the circulatory roadway BK [5,6] (edited by author).

Element	Mini roundabout	Small roundabout			
Outer diameter DA	13 m–22 m	26 m	30 m	35 m	≥ 40 m
Circulatory roadway width BK	400 m–500 m	900 m	800 m	700 m	650 m

If pronounced traffic peaks are to be expected during the course of the day, the permissible application range drops to up to 50% of these values. According to RVS 03.05.14, the traffic ratio of the intersecting roads should not fall below a factor of 1:4, as otherwise the traffic on the higher-ranking road would be slowed down too much and entry into the roundabout from the lower-ranking road would be considerably more difficult. An estimate of the capacity of roundabouts for different types of roundabouts can be shown in simplified form in **Figure 3**. Based on the traffic volume in the roundabout above the respective access Qkx, the respective permissible traffic volume of the entry relation Qe can be read off [2].

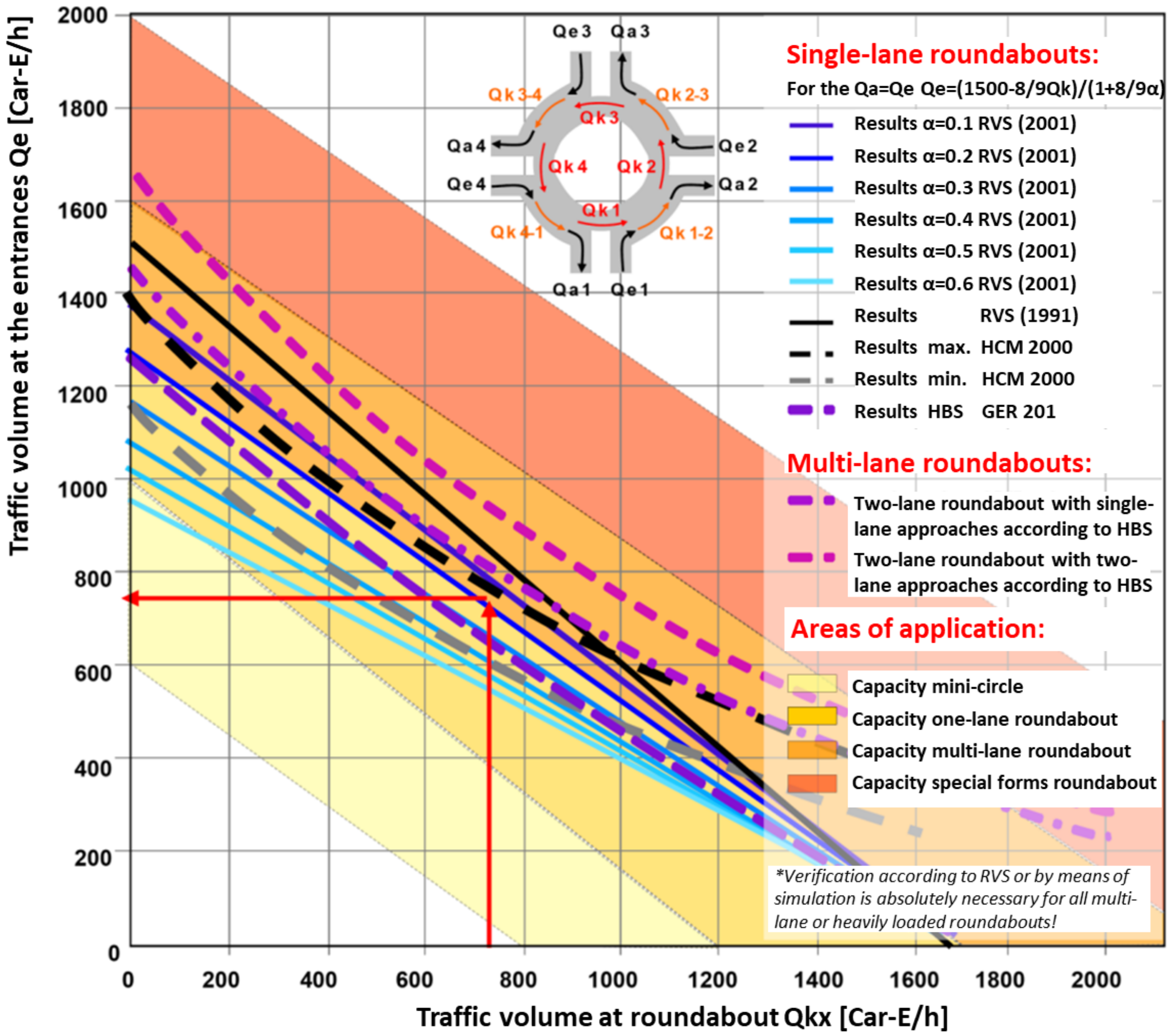

Figure 3. Estimating the efficiency of roundabouts [Car-E/h] [1] (edited by author).

Figure 4 (below) also shows a comparison of the area of application of different types of roundabouts and junctions. The permissible daily traffic load of the intersection and roundabout types is calculated from the total load of the intersecting roads [2].

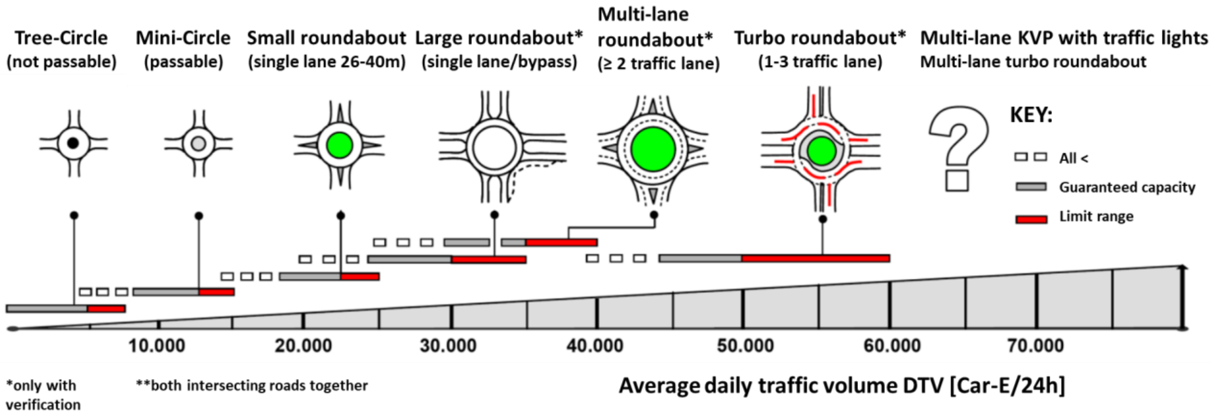

Figure 4. Capacity of roundabout types according to daily traffic load DTV [Car-E/24h] [2] (edited by author).

4. Elements of the roundabout

4.1. Definitions

The following definitions are taken from Austrian guidelines for planning, construction and maintenance of roads—planning, dimensioning and designing: intersections at grade—roundabouts [3] (**Figure 5**).

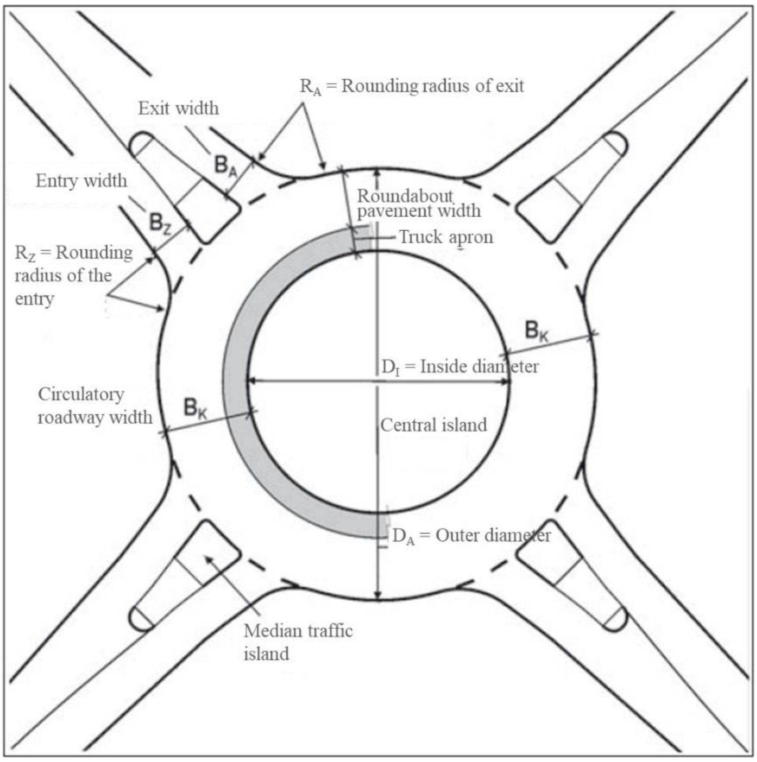

Figure 5. Definition of individual design elements and dimensions of a roundabout (system sketch) [5,6] (edited by author).

Roundabout: A junction where several roads meet at the same level in a circular roadway.

Mini roundabout: Roundabout with an outer diameter of less than 26.00 m and a passable central island.

Single-lane roundabout: Roundabout with a single-lane roadway and single-lane entrances and exits.

Multi-lane roundabout: Roundabout with a multi-lane circular roadway and single or multi-lane entrances and exits.

Roundabout arm: Road that leads into a roundabout.

Entrance (AUT)/Circular access (GER): Lane of a roundabout arm leading to the circular roadway.

Exit (AUT)/roundabout exit (GER): Lane of a roundabout arm leading away from the roundabout roadway.

Roundabout pavement: Single or multi-lane, approximately circular carriageway to connect the entrances and exits of a roundabout.

Central Island (AUT)/Circular Island (GER): The central island is the area within the circular roadway, which—except for mini roundabouts—is designed to be impassable.

Outer diameter: The outer diameter of a roundabout is measured at the outer edge of the circular roadway.

Bypass: Separate lane for right turners, which is separated from the circular roadway.

Relevant vehicle: Design vehicle whose tow curve is to be used for the test of passability.

4.2. Basic principles for the design of a roundabout

4.2.1. General

The center island of a roundabout fulfils both functional and design purposes. Certain requirements and principles must be considered during planning and realization. Some aspects differ depending on the location of the roundabout, whether it is inside or outside built-up areas [5].

4.2.2. Identity-creating effect of a roundabout

By designing roundabouts, visual accents can be set in the townscape and routes can be interrupted. Ideally, they create a connection to the location through specifically chosen themes and contribute to the formation of identity. They emphasise central inner-town junctions and squares and offer the opportunity to incorporate artistic, cultural-historical and locally significant design elements [6].

4.2.3. Harmonious design of a roundabout

Lettering, coats of arms, artwork and other design elements must not overload the centre island. Their size and proportions should be carefully selected and adapted, considering the speed at which road users enter the centre island. A successful design is characterised by a few, well-staged and harmoniously coordinated elements that also ensure good visibility from a distance. If structural elements are combined with planting, care should be taken to ensure that colours and structures are well coordinated.

4.2.4. Creating spaces

The inclusion of the surrounding green spaces in the design of such traffic junctions creates an overall urban situation reminiscent of a square [7].

4.2.5. Preventing the view through a roundabout

Another important safety aspect is the prevention of a direct view of the access road opposite. This obstacle increases the attention of road users. This point is particularly important outside built-up areas, as higher speeds are common here. A missing obstacle can be particularly problematic at night, as the oncoming headlights of a vehicle 'suggest the continuation of the carriageway' in the absence of street lighting. For this reason, outside built-up areas, it is important to raise the centre island and plant additional shrubs to break up the lines of sight. (cf. ibid.) At roundabouts which, due to their size, require both an embankment and an additional lane for heavy goods traffic, this lane is usually planned from one exit to the opposite entrance across the centre island, while the adjacent areas are embanked. This also ensures that the road is passable and interrupts the view [6].

4.2.6. Safety and early recognisability of a roundabout

An approaching roundabout must be visible and clearly recognisable to approaching drivers at an early stage, both in daylight and in the dark, in order to ensure a low speed level when entering and passing through. Timely recognisability is achieved by installing directional signs with the roundabout symbol. In addition, targeted illumination at night contributes to better visibility. It can also be advantageous if the centre island acts as an obstacle and specifically blocks the view of the rest of the road in order to increase driver awareness [8]. The central principle when planning roundabouts is to ensure the safety of all road users. It is essential that a roundabout is visible at an early stage so that approaching vehicles automatically reduce their speed when they see the obstacle. The resulting lower entry speeds minimise the risk of serious accidents and promote safe traffic management. For reasons of road safety, no rigid obstacles may be placed on the circular island opposite the approaches to the junction, as these could cause serious accident consequences in the event of a collision with a vehicle. This applies in particular to trees, walls, steep and high kerbs, embankments, lighting columns or works of art. Instead, the boundary of the circular island should be designed with bevelled kerbs or other gently sloping borders. Vertical walls or raised kerbs are not permitted for the boundary of the island [6]. As far as the safety of cyclists at roundabouts is concerned, the following recommendations can be derived from the research results of UDV [9], which should be considered when revising the regulations for the design of roundabouts:

- Roundabouts should have an outer diameter of at least 30 m, whereby the inner ring around the central island may be a maximum of three metres wide.
- In order to ensure effective speed reduction for vehicles entering the roundabout, the central islands should have a minimum diameter of 13 m.
- Inner rings should be structurally designed. An elevation of at least three centimetres compared to the carriageway and/or a particularly rough surface design is recommended in order to achieve a significant reduction in speed.
- Two-way traffic for cyclists should be avoided wherever possible. If this is unavoidable, cycle lanes should be at least 2 m wide and marked with pictograms and directional markings.
- Cycle lanes should be routed close to the carriageway before entering the roundabout. Particularly at the exits, a route close to the carriageway is preferable

due to the better visibility.

- The cycle path around the roundabout should be routed as close as possible to the carriageway. The distance between the cycle path and the edge of the carriageway should be less than 2 m and must never be greater than 4 m [9].

Pedestrians and cyclists benefit from the low speeds of motor vehicle traffic, the resulting cooperative traffic behaviour, the comparatively simple and clear traffic conditions and the short crossing distances. Furthermore, it is emphasised: Roundabouts also have a speed-reducing effect on the sections of road in front of and behind them, but this is limited to the immediate vicinity. A significant reduction in the range of around 60 m and a speed still well below the road speed level in the range of around 120 m has been observed [10].

4.2.7. Clarity of a roundabout

For road users, the roundabout should be clearly structured and easy to see when entering the access arm. It is therefore important that the view of the neighbouring access roads is unrestricted. This allows drivers to adjust their speed in good time. They have the opportunity to recognise other road users on the circular carriageway as well as approaching vehicles and to correctly assess their behaviour in terms of ‘defensive driving’. If no other road users are in sight, the roundabout can be driven through without stopping first [8]. With a designed centre island, road users should be able to take in all elements at a glance and quickly turn their attention back to the traffic. The design should therefore remain unobtrusive and avoid conspicuous or unusual details in order to avoid distractions and ensure clear traffic guidance [6].

4.2.8. Trafficability of a roundabout

A key functional requirement when designing a roundabout is the consideration of all road users. While the centre island cannot be used by vehicles in normal operation and is generally inaccessible to road users, it must be ensured during planning, especially for larger roundabouts, that heavy goods vehicles can pass the junction without major restrictions if necessary. As such transports occur more frequently outside built-up areas, there is often an additional lane on the centre island. This is slightly raised and has a different surface to the circular carriageway. In normal operation, these lanes are often closed off with easily removable bollards, barriers or signs. Within built-up areas, an additional ring surrounding the central island is usually provided, which stands out due to the choice of surfacing and is primarily intended for buses, low-loaders and lorries. This inner ring, which is usually around one to three metres wide, allows these vehicles to cross the actual carriageway without damaging the central island [11].

4.2.9. Passive protection of road users at roundabouts

The aspect of safety in the form of passive protection for road users must also be considered for fixtures and planting. The edges or kerbs of a raised central island must not be too steep or too high. This also applies to the aforementioned elevation. In order to minimise the risk of serious accidents, trees (with a circumference of more than 25 cm), lighting columns and sharp edges and pointed elements on artworks near access roads should be avoided. This rule is particularly important outside built-up areas due to the higher speeds there. Installations should generally be designed in such a way that they can be easily driven round or deformed in the event of a collision, or they should be laid out flat. Filigree art objects and water features are well suited for this purpose. Plantings should be as low as possible and without visible trunks. As there are no specific guidelines in this area that specify clear values or rules, this aspect of planning is subject to a process of consideration and coordination with the relevant authorities.

4.2.10. Planting of a roundabout

When planting roundabouts, care should be taken to ensure that the plants chosen stand out clearly from the background. This contributes to the early recognisability of the roundabout. The planting should not only be aesthetically pleasing but also, if possible, create a sense of identity for the surrounding area. In addition, it is ideal to use plants with high biodiversity to counteract the current decline in insect species and diversity. It is recommended to keep the edge area of the central island about 0.50 to 1 metre clear or to pave it. This area is exposed to strong influences such as road salt in winter, drought and intense sunlight in summer as well as the weight of lorries driving over it. In addition, keeping the verge clear ensures that road users have an unrestricted view of the access road, thus guaranteeing road safety.

4.2.11. Lighting of a roundabout

Roundabouts are generally only illuminated within built-up areas. In unlit open areas, lighting is not generally required unless certain exceptions apply. Roundabouts should be illuminated if [12]

- Roundabout has a high traffic significance.
- The roundabout is located on an illuminated section of road.
- Crossing aids with significant pedestrian flows are present.
- Traffic conditions are unclear (e.g., atypical traffic flows, difficult orientation, etc.).
- There is an accumulation of accidents at dusk and in the dark.

4.3. Empirical models based on the geometric and functional parameters of various roundabouts

In the study by Al Hasanat and Juhász [13], the critical gap values of the thirteen roundabouts were estimated manually using the Raff method. Some geometric data of the roundabouts were obtained from vector maps of the Hungarian Road Administration, while the rest were determined using Google Maps. The traffic volume was extracted manually from the recorded videos of the selected roundabouts. The influence of pedestrians and cyclists was not considered in this study. After data collection, various statistical methods were used to determine the optimal prediction model. Statistical packages in Python were used for the statistical analysis. Three statistical models were set up to develop the prediction model:

- Multivariate adaptive regression spline (MARS) as model 1 (M1),
- a linear regression model based on the Pearson correlation coefficient as Model 2 (M2),
- and a linear regression model based on the Spearman correlation coefficient as model 3 (M3).

Following the study, all three models were compared with each other. The model with the highest coefficient of determination (R^2) and the lowest root mean square error (RMSE) was determined to be the best prediction model for the critical gap. A 3D colour map for the selected MARS function is shown in **Figure 6**.

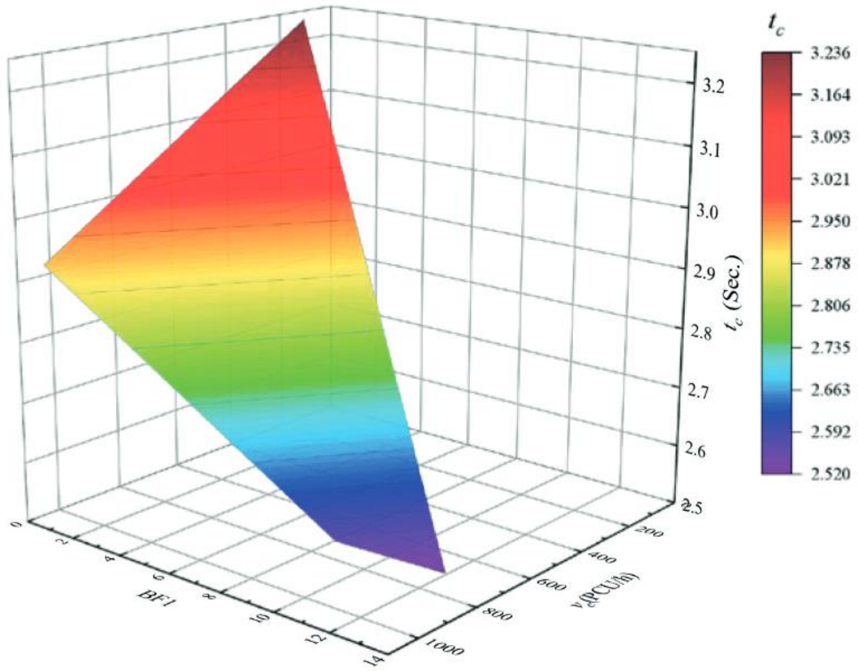

Figure 6. The dependence of the critical gap as a function of circulating volume and distance between neighboring legs for the selected Mars model [13].

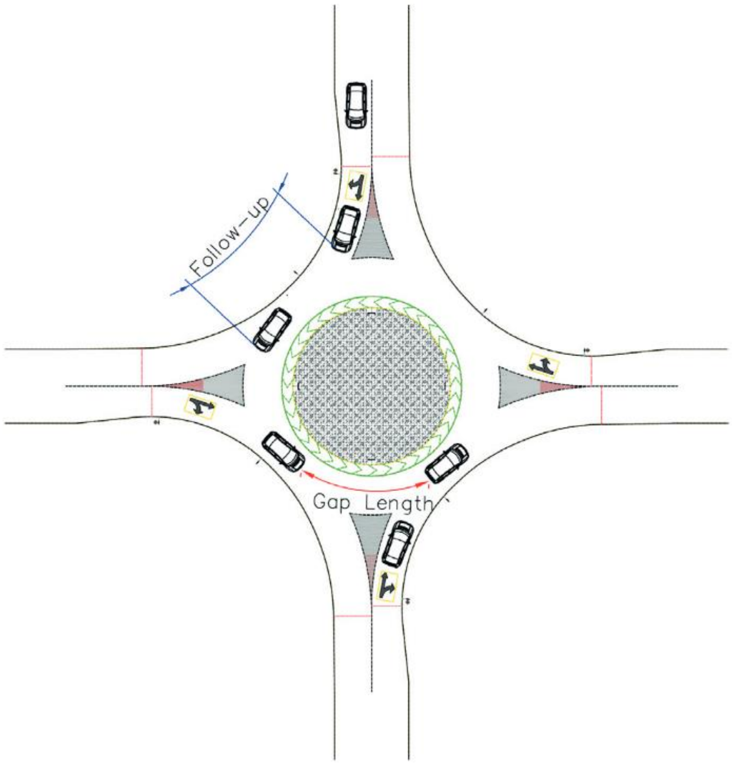

Figure 7. Gap and Headway [13,14].

In the study by Al Hasanat and Juhász [13] and Haitham and Schuchmann [14], the relationship between critical gap and certain geometric parameters in roundabouts was analysed using the gap acceptance method (**Figure 7**).

The gap acceptance method is one of the classic methods for analysing the capacity of roundabouts. The critical gap plays a central role here. Different driving behaviour and local traffic regulations have a significant influence on the application of this method in the national standards for capacity calculation in each country. When investigating the parameters that mainly correlate with the critical gap, the entry width, the distance between neighbouring legs and the entry width were identified as the most important factors. For the sensitivity analysis, a meta-model was created that enables a linear mapping of the measured parameters to the value of the critical gap. Prior to the meta-modelling, the various parameters were adjusted using a MinMax scaler so that all scaled parameters lie between 0 and 1. This was necessary because the different scaling of the measured parameters compared to the critical gap can lead to unequal contributions in the model fitting and cause distortions. The model was then calculated by regression using Linear Regression model of sklearn. The distance between the neighbouring legs and the entry width showed a correlation with the critical gap, with the entry width showing a negative correlation. This means that as the entry width decreases, the critical gap increases [13,14].

4.4. Design principles

4.4.1. Outer diameter

To FGSV [5,6] the outer diameter of roundabouts in Germany is according to **Table 2**. For small roundabouts the outer diameter must be at least 26 m, if the roundabout island cannot be crossed Outer diameters larger than 40 m should be avoided. For mini roundabouts the outer diameter should be at least 13 m (GER), so that the circle island does not become too small. Larger outer diameters make it easier for heavy goods vehicles to pass. For roundabouts with 2-lane traffic, the outer diameter must be at least 40 m (GER) for geometrical reasons alone.

Table 2. Outer diameter DA of roundabouts in Germany FGSV [5,6] (edited by author).

Application limits	Mini roundabout	Small roundabout
Minimum value	13 m	26 m
Regulation value	-	30–35 m
Upper limit	22 m	40 m

In Austria, the outer diameter is <26 m for mini-roundabouts, ≥26 m for single-lane roundabouts and ≥40 m for multi-lane roundabouts [3].

4.4.2. Roundabout entry, roundabout exit

The roundabout arms are to be distributed as evenly as possible around the circumference of the circle. The entrance to the roundabout is to be approached so that it touches the ring at a right angle. The ring road at a right angle. The axes of the roundabout arms should be guided as directly as possible into the center of the roundabout (**Figure 8**). The exit from the roundabout can also be approximately tangential.

Since, for traffic reasons, the speed at the entrance should be lower than at the exit, the entrance radius should be the entry radius should be smaller than the exit radius. For the radius should be approx. 12 m for roundabouts with a diameter of 35 and 50 m, and approx. 25 m for the exit radius, approx. 25 m for the exit radius (**Figure 8**).

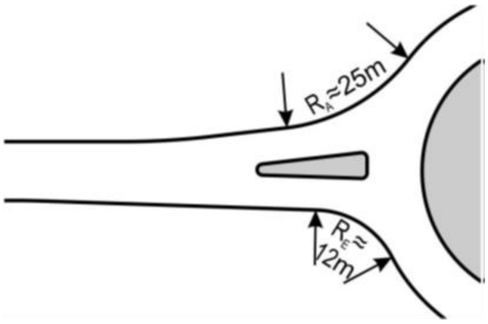

Figure 8. Entry and exit radii [15].

4.4.3. Circulatory roadway, roundabout pavement, truck apron

For traffic safety, the circulatory roadway must be circular. By way of derogation from this rule, a roundabout may be constructed where urban planning requirements dictate that the roundabout pavement consists of two semicircles of equal radius connected by straight sections. The length of the straight lines should then be greater than the radius of the semicircles. The width of the circulatory roadway of roundabouts in Germany depends on the outer diameter (**Table 1**) [5,6].

The circulatory roadway should be divided into the roundabout pavement and a truck apron in a ratio of about 3:1. This is particularly necessary for the safety of cyclists when they are guided on the roundabout pavement and supports the speed-damping effect by increasing the deflection of the driving lines of passenger cars [5,6].

To FSV [3], the width of the roundabout pavement in Austria for single-lane roundabouts is between 6.50 and 9.00 m, depending on the tracktrix curve[1] of the decisive design vehicle. Attention must be paid to the intended deflection through the central island. For a two-lane roundabout, the roundabout pavement must be between 8.00 and 10.00 m wide (AUT).

4.5. Central Island (AUT)/District Island (GER)

The central island should be designed to be perceived as an obstacle upon approach. At roundabouts with an outside diameter of more than 35.0 m, the central island should prevent the view from the approach road straight ahead to the opposite exit. This can be achieved with various design options such as trees in the central island (**Figure 9**).

Viewed from a distance, three trees appear to stand in a line in the middle of the road (**Figure 9**). However, when you get very close to the roundabout, it is only then that you realize that these three trees are actually situated in the shape of a triangle and not in a line (**Figure 10**).

Figure 9. Three trees in the central island seen from a distance [16].

Figure 10. Three trees in the central island seen from close up [16].

More elaborate designs, such as a castle with surrounding animal figures, can also be considered (**Figures 11** and **12**).

Figure 11. Artistic design of the central [17].

Figure 12. “Pets” in front of the castle [17].

However, some roundabouts with specially designated special transport routes must provide a passage for these oversized vehicles in the form of the passable areas through the central island (**Figures 13** and **14**).

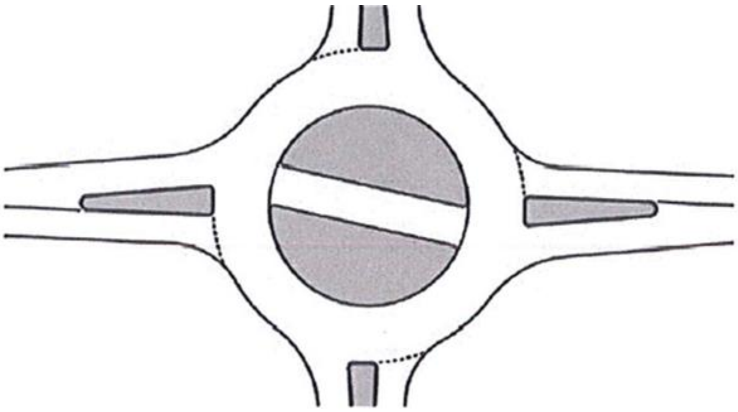

Figure 13. Passable central island [3].

Figure 14. Example of a roundabout with the passable central island [16].

In the case of mini roundabouts (outer diameter from 13 m), the central island must be designed in such a way that it can be crossed by buses and trucks at low speeds. The central island can be crossed by means of curbstones 4–5 cm high (**Figure 15**).

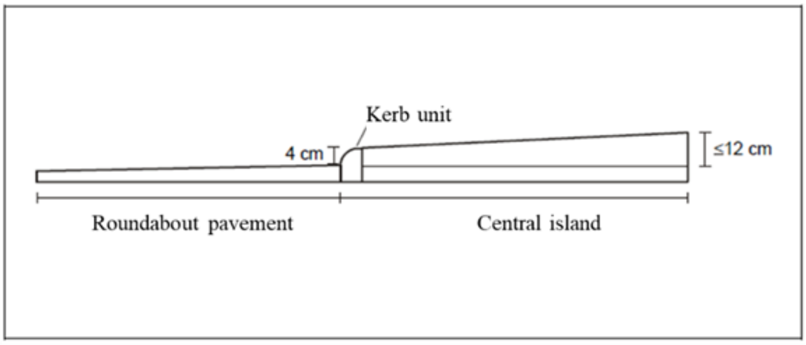

Figure 15. Formation of curbs at mini roundabouts [18].

The tractrix curves (also known as “tractory curves”) (**Figure 16**) describe the area swept by a vehicle (when cornering) in the plan projection and thus represent the area required by a vehicle for a specific movement sequence (course of travel)[1]. Cars should not drive over the central island in mini roundabouts, because it is not necessary (**Figure 17**).

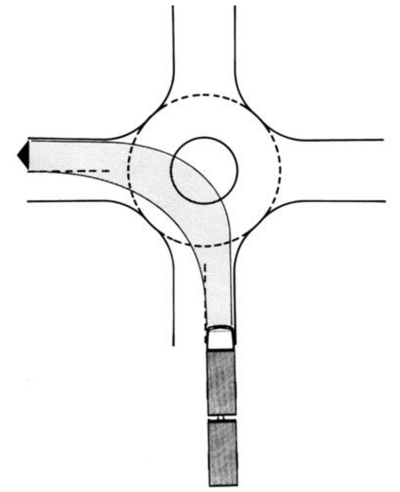

Figure 16. Tractrix curve of a truck in a mini roundabout [16].

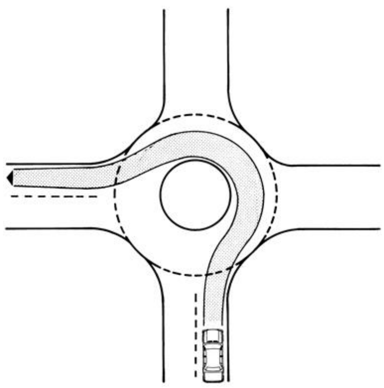

Figure 17. Tractrix curve of a car in a mini roundabout [16].

An example of a mini roundabout with a passable, red-marked central island can be seen in **Figure 18**.

Figure 18. Mini roundabout with a passable central island in the author's place of residence [16,17].

To FGSV [5,6] the diameter of the island (D_I) should be at least 4.00 m (GER). The center of the central island should be located at the intersection of the roundabout arms (**Figure 19**). In this way, the central island represents a diversion of the entry traffic and thus the so-called "privileged traffic flows" with higher speeds to the other traffic flows are avoided.

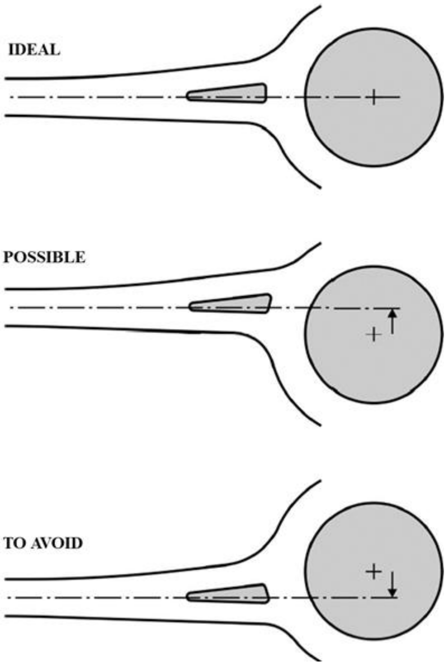

Figure 19. Position of the axes of roundabout arms [15].

4.6. Median traffic island

The median traffic island should always be provided if possible and are also useful for mini roundabouts. They are placed between the entrances and exits at the roundabout arms to avoid wrong turns and to provide more traffic safety especially for pedestrians and cyclists.

The width of the median traffic island is at least 1.60 m or 2.00 m [3]. In the area of the crossing aid, the median traffic island must be constructed at least 2.50 m (**Figure 20**). The median traffic island is to be bordered with curbstones and lowered in the area of the crossing point as a 2–3 cm high low curb.

The median traffic island is to be placed 0.25 m from the circular roadway and its length is 12.00 to 15.00 m depending on the local space conditions. The width of the median traffic island at its tip is at least 1.10 m (width of the guide angle + 2 × 0.30 m). The distance between the crossing points (zebra) and the circular roadway should be 6.0 m, so that a car can remain inside until the circular roadway is clear, without preventing the crossing with its rear part. The crossing width should be at least 2.50 m, with 3.00 m being preferable [15]. In the lane divider it is also possible to place an exit sign, taking care not to obstruct the visibility of all road users (**Figure 20**).

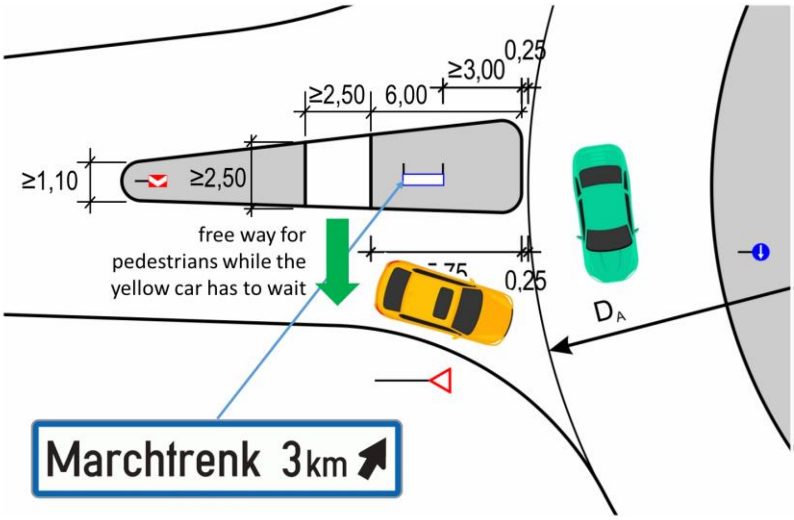

Figure 20. Median traffic island with crossing point [15] (edited by author).

4.7. Bypass on the roundabout

The bypasses are the right-turn lanes outside the circular roadway and they serve to increase the capacity of the roundabouts, with special attention to the safety and guidance of pedestrians and cyclists. In case of strong crossing pedestrian flows, bypasses may only be arranged if they are absolutely necessary for reasons of efficiency. If pedestrian or cyclist crossing points are to be crossed by a bypass, the speed at the bypass must be kept as low as possible (e.g., by means of suitable routing), the bypass must in any case be structurally separated and the directional island in the area of the crossing point must normally be 2.5 m wide (min. 2.0 m). The directional island must be lowered in the area of the crossing point. There are basically two types of bypasses [3]:

1) In one archway, quickly (without counter archway)
2) In a counter archway, adapted to save space.

The width of the lane of a bypass results from the tractrix curve of the decisive vehicle plus 0.50 m safety distance on both sides. The bypass must be separated from the roundabout pavement by a directional island (e.g., green strip) with a width of at least 1.50 m. In order to avoid backwater, the bypass must be given priority [15].

As a rule, the bypass in the direction of travel begins with a right-turn lane (at least 20 m long) and ends with a right-turn lane (at least 75 m long). The warping of the right-turn lane is to be formed 1:10 and right-turn lane 1:20. The directional island separating the bypass from the roundabout entrance and exit should start at least 20 m before the roundabout pavement and extend to at least 20 m after the roundabout pavement [3,15] (**Figure 21**).

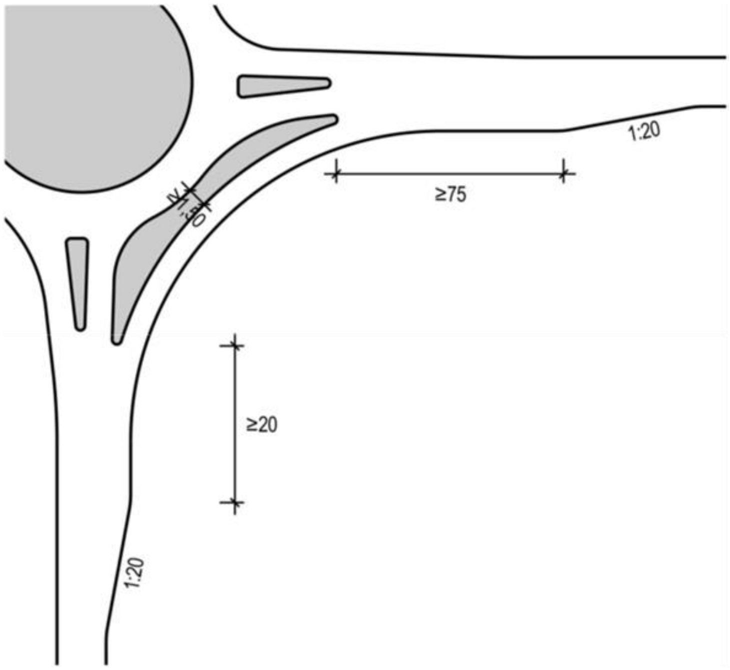

Figure 21. Bypass with right-turning lane and right-turning lane as a rule [15].

An example of a bypass shows in **Figure 22**.

Figure 22. Example of a bypass [17].

5. Conclusion

Vehicles move slower at roundabouts than they do at other intersections, giving one road priority. Traffic patterns in the intersection area and aesthetic considerations play a major role in the layout of a roundabout. The requirements of public buses, municipal and emergency vehicles must be considered when designing such amenities. After considering the turning paths of design vehicles, curbs may be used to create a boundary. Alternately, island regions can be paved and made accessible in part or full. The central island should be designed to fit the location. There is a central island around which vehicles circulate. It deflects vehicles and needs to be prominent at the intersection. The design of the central island should be tailored to the local conditions. When planning the central island, the needs of bus traffic as well as municipal and emergency vehicles must be taken into account. Besides aesthetic considerations, the geometric layout of the intersection plays a crucial role in roundabout design. If there is sufficient residual space after considering the turning radii of specific vehicles, delineation can be achieved using raised curbs. Alternatively, island areas marked by paving, partially or entirely traversable, can also be utilized. The central island and median island are pivotal components of a roundabout, significantly impacting traffic flow and road user safety. The central island should be configured to be perceived as an obstacle during approach. In roundabouts with an outer diameter exceeding 35.0 meters, the central island should obstruct the view from the approach road straight across to the opposite exit. This can be accomplished through various design features, such as incorporating trees within the central island.

Conflict of interest: The author declares no conflict of interest.

Notes

[1] Tracktrix curves (also known as "driving curves") describe the area swept by a vehicle (when cornering) in the floor plan projection and thus represent the area required by a vehicle for a specific sequence of movements (driving directions).

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