CETRA2026 27-30 May 2026, Bol, Island Brač, Croatia
9th International Conference on Road and Rail Infrastructure

URBAN ROUNDABOUTS NEAR SIGNALISED INTERSECTIONS: REVIEW AND PRELIMINARY MICROSIMULATION FINDINGS

Mirna Klobučar[1], Aleksandra Deluka-Tibljaš[1], Sanja Šurdonja[1], Irena Ištoka Otković[2], Marijana Cuculić[1]
[1]*University of Rijeka, Faculty of Civil Engineering, Rijeka, Croatia*
[2]*Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering and Architecture Osijek, Croatia*

Abstract

Roundabouts are increasingly used worldwide to improve traffic safety, operational performance, and sustainability, yet design guidance varies widely across countries. Most guidelines focus on isolated roundabouts and rarely address how nearby intersections, especially signalized ones, affect performance; where they do, recommendations are mostly qualitative. This paper reviews selected national and international guidance for urban settings and proposes a corridor-level methodology combining traffic analysis with microsimulation to assess roundabouts near signalized intersections. Preliminary results show that short spacing between junctions can degrade performance and raise the risk of queue spillback into the circulatory roadway. Traffic volume is the dominant factor, with the major/minor flow split also significantly influencing outcomes. The results highlight the need for corridor-scale evaluation when integrating roundabouts and signals in urban networks.

Keywords: roundabout, urban network, intersection spacing, microsimulation model, design guidelines, signalized intersection

1 Introduction

Roundabouts are being increasingly integrated into urban traffic networks due to their potential to enhance both operational efficiency and traffic safety compared to conventional at-grade intersections [1]. Their broader benefits, however, are not determined only by the geometry and control of the roundabout itself. Instead, it depends strongly on how successive junctions interact as a coordinated system, particularly when a roundabout is introduced near a signalized intersection. In such settings, traffic progression, platoon dispersion, and available queue storage become decisive corridor-level constraints [2, 3]. Traditional approaches in traffic engineering often consider roundabouts as isolated elements, overlooking their interactions with adjacent junctions, particularly nearby signalized intersections. This oversight is important because combining control regimes can create non-uniform driving conditions (yield control versus time-separated signal control), making stable operation under peak demand harder to achieve. When spacing is inadequate, queues from the signalized intersection can spill back into the roundabout's entry or circulatory roadway, reducing capacity, degrading level of service, and potentially increasing conflict exposure [4]. The goal of this paper is to review selected national and international guidelines for urban roundabouts near signalized intersections and to present preliminary microsimulation results that quantify how junction spacing, peak-hour traffic volume, and major/minor flow distribution influence corridor performance.

This paper is a part of broader doctoral research aimed at analyzing operational and safety performance and optimizing the distance between roundabouts and signalized intersections [5].

2 Review of technical regulations for the planning and design of roundabouts

A comparative review of technical regulations for roundabout design was carried out across 11 countries in Europe and worldwide. The analysis reveals substantial cross-country variation, both in the level of detail provided and, in the criteria, used to determine when roundabouts are appropriate, as well as in the selection of key design elements. In continental Europe, including Germany [6], France [7], and the Netherlands [8], roundabouts are often implemented as traffic-calming measures, with a strong emphasis on safety, particularly for pedestrians and cyclists. Anglo-Saxon countries such as the UK [9], the US [1], and Australia [10] have more extensive guidance covering a broader range of roundabout types, with a greater focus on improving traffic capacity and allowing more flexibility in design choices. In table 1 are presented the descriptive statistics of the minimum and maximum recommended values for selected roundabout design parameters across the 11 reviewed countries, including outer radius (R) [m], circulatory roadway width (u) [m], entry radius (R_{en}) [m], exit radius (R_{ex}) [m] and central island radius (R_c) [m].

Table 1 Descriptive statistics of recommended minimum and maximum values for selected roundabout design parameters

	Min recommended values					Max recommended values				
	R	**u**	R_{ent}	R_{ex}	R_c	**R**	**u**	R_{ent}	R_{ex}	R_c
Min	13.0	4.5	6.0	10.0	6.0	18.0	5.5	12.0	14.0	8.0
Max	15.0	7.2	20.0	20.0	10.0	30.0	16.2	100	100	18.0
Mean	14.3	5.4	10.4	15.4	7.9	21.8	9.5	44.1	47.2	13.1
Std. dev.	0.9	0.8	3.8	3.8	1.0	4.4	4.5	37.1	39.9	3.1

Technical guidelines and regulations in Europe and worldwide predominantly address isolated roundabouts, focusing on geometric design elements and performance comparisons with conventional at-grade intersections (priority-controlled or signal-controlled). Although many documents [1, 6, 7, 11, 12] acknowledge that intersections interact within a broader network or corridor, this interaction is usually discussed only in general, descriptive terms, with limited operational definitions or explicit spacing criteria. Numerical spacing values are more commonly defined for standard rural intersection cases, whereas urban applications are typically addressed through case-by-case assessment. This section synthesizes similarities and differences in international guidance concerning: (1) roundabouts in series (multiple roundabouts along a corridor) and (2) mixed corridors combining roundabouts with signalized intersections

2.1 Roundabouts in series (closely spaced roundabouts)

U.S. guidelines [1] provides comparatively detailed direction on closely spaced roundabouts and strongly emphasizes microsimulation when roundabouts are evaluated as part of a network. Specifically, when the center-to-center spacing between two roundabouts is $<$ 300 m, the U.S. approach indicates that a double roundabout should be considered, accompanied by verification of approach queues and the available storage length between nodes.

The intended operational benefits include shorter queues, better flow distribution, reduced speeds along the main corridor, and improved access management for adjacent properties, provided that inter-roundabout storage is adequate. Comparable criteria appear in Norwegian [13] and British [9] practice: a double (or large) roundabout is recommended when center-to-center spacing is ‹ 100 m, with a minimum permissible spacing of 40 m in the double-roundabout configuration. German guidelines [6] additionally warns that a sequence of roundabouts may blur drivers' perception of road hierarchy and therefore recommends avoiding such solutions where feasible.

2.2 Interaction between roundabouts and signalized intersections

Across countries, there is broad agreement that combining roundabouts and signalized intersections within the same corridor is generally undesirable. The principal rationale is the introduction of non-uniform driving regimes and the practical difficulty of coordinating flows. These effects can reduce capacity, increase delay, and intensify congestion, especially under peak demand and in corridors where progression is important. German [6] and British [9] guidelines are particularly explicit in advising that this combination should be avoided. Where a mixed corridor cannot be avoided, U.S. [1] and Australian [10] guidelines provide more concrete operational strategies. Common recommendations include corridor segmentation into sub-systems, in which signalized intersections operate on independent signal cycles rather than attempting full progression through a roundabout influence area; and/or partial signalization of the roundabout (or approaches) in specific, demand-driven situations. Explicit minimum spacings between intersections are rarely prescribed for urban corridors. Instead, most guidelines rely on principle-based criteria such as visibility and sight-distance requirements, stopping sight distance, and queue storage and spillback prevention (ensuring queues do not block upstream control points).
A more operationally specific discussion of spacing between a roundabout and a signalized intersection is found in U.S. guidelines [14], which states that a roundabout is generally undesirable near a signalized intersection. If the separation distance is ‹ 500 ft (≈ 152 m), a detailed corridor-level analysis is recommended, typically including microsimulation, to verify queue lengths, storage adequacy, and potential benefits of corridor segmentation. Under certain conditions, replacing a signalized intersection with a roundabout may be feasible if the corridor is divided into two coordinated segments, potentially improving the efficiency of each segment and the corridor overall. However, this requires explicit verification of operational performance and spillback risk. In table 2 a comparative overview is presented of international approaches to evaluating roundabouts within traffic corridors. The table summarizes (i) whether microsimulation (or alternative software-based methods) is recommended or required, (ii) whether any minimum distance between a roundabout and the adjacent intersection is explicitly stated, and (iii) how guidelines address the interaction between roundabouts and signalized intersections. Countries in which the application of technical regulations is legally mandatory are highlighted in bold.

Table 2 Comparison of international guidelines for roundabout design

Country	Microsimulation	Minimum distance from RB to the adjacent intersection	Interaction between RB and a signalized intersection
HR [11]	Yes (after analytical cal.)	–	–
SI [12]	Yes	–	–
DEU [6]	Yes (special studies)	Double RB if centre–centre < 100 m	Not recommended
FRA [7]	No	–	Not recommended
UK [9]	No (ARCADY/ RODEL).	Double/large RB if < 100 m; double RB min. 40 m	Not recommended
NDL [8]	Yes	–	Not recommended
NOR [13]	No (SIDRA)	Double/large RB if < 100 m; double RB min. 40 m	–
USA [1,14]	Yes	If < 500 ft (152,4 m), recommend microsimulation	Corridor subdivision or partial RB signalization
AUS [10]	No (SIDRA)	–	RB signalization

3 Preliminary analysis

In previous study [15] the interaction between a single-lane urban roundabout and a nearby two-phase signalized intersection was investigated with VISSIM microsimulations. To create a representative microsimulation network in VISSIM, the authors established a standard medium-sized urban roundabout with an outer radius of 17 meters and utilized the average vehicle composition derived from the field dataset. The peak-hour traffic volumes were systematically adjusted to represent 5–10% of the roundabout's capacity of 20,000 vehicles per day, resulting in peak hour volumes of 1,000, 1,200, 1,400, 1,600, 1,800, and 2,000 vehicles per hour. Traffic distribution between major and minor directions was examined at ratios of 70:30, 60:40, and 50:50, while the distance between the roundabout center and the signalized intersection varied from 40 to 120 meters.

Results were analyzed using standard traffic indicators, including queue length, delay, stops, emissions, and fuel consumption. Of particular importance for assessing corridor performance was the travel time measured over a 300-meter route that encompassed the interaction zone. In the case of the isolated roundabout, operations remained generally stable at traffic volumes of 1,000 to 1,400 vehicles per hour (with vehicle delays averaging less than approximately 20 seconds per vehicle and travel times under 60 seconds). However, at volumes of 1,800-2,000 vehicles per hour, the system approached saturation, with 15-22% of vehicles unable to pass during the simulation period. When the signalized intersection was introduced, short spacings of less than 50 meters consistently resulted in the worst outcomes. This was due to queues forming at the signal, which spilled back into the roundabout, leading to increased delays and travel times. The study indicates that travel times in these short spacing scenarios were approximately 30–40% higher compared to isolated cases. As the spacing increased, performance improved: at around 60–80 meters, the interaction effects were classified as "intermediate, " and at distances of 100 meters or more, the corridor began to behave increasingly like an isolated roundabout, reducing the occurrence of congestion propagating into the roundabout. Additionally, flow distribution played a significant role: a 50:50 split can be advantageous at lower volumes, but under high demand, it may worsen system-wide congestion as both approaches become heavily loaded simultaneously.

A significant contribution of the paper is the development of a travel-time prediction model based on a dataset of 180 scenarios, utilizing stepwise multiple linear regression. The resulting three-variable model achieved an R^2 value of 0.909, with a root mean square error (RMSE) of 15076 seconds. The model is expressed as follows:

$$Travel\ time = -79.741 + 0.136 \cdot PHV - 28.977 \cdot MDP - 0.026 \cdot D \quad (1)$$

Where:
- *Travel time* [s]: the travel time along a 300 m route, accounting for both roundabouts and signalized intersections (in seconds)
- *PHV* [veh/h]: the peak-hour traffic volume at the roundabout
- *MDP*: the percentage of peak-hour volume in the major direction (e.g., 0.7)
- *D* [m]; the distance between the roundabout and the signalized intersection.

All three parameters were found to be statistically significant, with peak-hour traffic volume having the strongest influence on the travel time, as shown in table 3.

Table 3 Correlation matrix of the model

	PHV	MDP	D	Travel time
PHV [veh/h]	1	0.000	0.000	0.941
MDP [/]	0.000	1	0.000	−0.048
D [m]	0.000	0.000	1	−0.145
Travel Time [s]	0.941	−0.048	−0.145	1

In further research [5], the analysis was extended to include greater distances between a roundabout and a nearby signalized intersection, as well as variations in the outer radius and traffic signalization. The results show that increasing the spacing between intersections significantly reduces vehicle delay and travel time, while short distances lead to pronounced negative interactions. These adverse effects become particularly evident under higher traffic demand. Although larger spacing improves performance, the interaction between closely located intersections does not disappear entirely. Isolated roundabouts consistently provide the most favorable operational results. The findings also reveal that even with a 160 m spacing between intersections, a significant negative interaction remains, contrary to U.S. guidelines [14], which suggests that at this distance, mutual influence should be negligible. Additionally, a larger outer radius of the roundabout improves traffic performance, especially in high-demand conditions. Nevertheless, the presence of a nearby signalized intersection increases overall travel time in all scenarios, with the strongest impact observed at the shortest spacing. Overall, both intersection spacing and roundabout geometry substantially influence operational efficiency.

4 Conclusion

This paper explores selected national and international guidelines regarding urban roundabouts, with particular emphasis on corridors where roundabouts are situated near signalized intersections. The review highlights significant cross-country variations in design criteria for roundabouts and indicates that most guidelines continue to regard roundabouts as standalone facilities. In the guidelines, which recognize the importance of the interaction between the roundabout and adjacent intersections [6, 7, 11, 12], the recommendations tend to be qualitative, suggesting a case-by-case approach.

These assessments typically center on aspects such as queue storage, spillback prevention, and, in some documents, the recommendation of microsimulation as a suitable evaluation tool. This paper outlines a corridor-level assessment approach that combines analytical analysis with traffic microsimulations, enabling direct testing of operational interaction effects. Preliminary VISSIM findings [15] indicate that short spacing between a single-lane urban roundabout and a two-phase signalized intersection can significantly degrade corridor performance, primarily through queue spillback from the signal into the roundabout circulatory roadway. Across the tested scenarios, peak-hour traffic volume emerged as the dominant driver of performance deterioration, while the major/minor flow split and the spacing distance also influenced outcomes in measurable ways. In particular, very short separations (below 50 m in the tested setup) consistently produced the highest delays and travel times, whereas increasing separation reduced interaction effects and allowed the corridor to behave progressively more like an isolated roundabout. The results reinforce a central implication for urban practice: the suitability of a roundabout near a signalized intersection cannot be judged reliably by using isolated-intersection logic alone. Corridor-scale evaluation is essential, and microsimulation provides a practical framework to support this. The presented outcomes are preliminary, and the next research steps should expand the tested geometric and control conditions, calibrate them with additional field data, and further validate predictive relationships to develop more operationally specific spacing guidance for urban networks.

Acknowledgments

This research was funded by the European Union – NextGeneration EU ("Optimizing Transport Infrastructure in the Function of Sustainable Mobility in the Cities, ", a scientific project at the University of Rijeka (uniri-iz-25-32) and "Safety aspects of urban transport infrastructure-SigINFRA", a scientific project at the Josip Juraj Strossmayer University of Osijek (581-UNIOS-71)).

References

[1] National Cooperative Highway Research Program Guide for Roundabouts (Report 1043), Transportation Research Board, 2023.

[2] Hallmark, S., Fitzsimmons, E.J., Isebrands, H.N.; Giese, K.: Roundabouts in Signalized Corridors: Evaluation of Traffic Flow Impacts, Transp. Res. Rec, 2182 (2010), pp. 139–147, DOI: https://doi.org/10.3141/2182-18

[3] Brocchini, L., Pratelli, A., Josselin, D., Losa, M.: A Microsimulation-Based Methodology for Evaluating Efficiency and Safety in Roundabout Corridors: Case Studies of Pisa (Italy) and Avignon (France), Infrastructures, 10 (2025) 186, DOI: https://doi.org/10.3390/INFRASTRUCTURES10070186

[4] Akçelik, R.: Modeling Queue Spillback and Nearby Signal Effects in a Roundabout Corridor, 4th International Roundabout Conference, Seattle, Washington, 16-18 April 2014.

[5] Klobučar, M.: Optimizacija udaljenosti kružnog raskrižja od susjednog iz aspekta pokazatelja prometnog toka i sigurnosti prometa, doctoral thesis, University of Rijeka, Faculty of Civil Engineering, Croatia, 2025.

[6] Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV) Richtlinien für die Anlage von Kreisverkehren, Köln, Germany, 2006.

[7] Centre d'études et d'expertise sur les risques, l'environnement, la mobilité & l'aménagement (Cerema) Guide des carrefours urbains, Lyon, France, 2010.

[8] Centrum voor Regelgeving en Onderzoek in de Wegenbouw en de Verkeerstechniek (CROW) Richtlijn rotondes (Publicatie 257), Ede, Netherlands, 2015.

[9] National Highways Geometric design of roundabouts, UK, 2023.

[10] Austroads Guide to road design, Part 4B, Roundabouts, Sydney, Australia, 2023.

[11] Hrvatske ceste Smjernice za projektiranje kružnih raskrižja na državnim cestama, Rijeka, Hrvatska, 2014.

[12] Direkcija Republike Slovenije za ceste Tehnička specifikacija za javne ceste - krožna križišča, Ljubljana, Slovenia, Slovenija, 2012.

[13] Statens vegvesen Håndbok V121: Geometrisk utforming av veg- og gatekryss, Oslo, Norway, 2023.

[14] Wisconsin Department of Transportation Facilities Development Manual (T439), Wisconsin, SAD, 2022.

[15] Klobučar, M., Deluka-Tibljaš, A., Šurdonja, S., Ištoka Otković, I.: A Theoretical Model for Optimizing Signalized Intersection and Roundabout Distance Using Microsimulations, Future Transportation, 5 (2025) 28, DOI: https://doi.org/10.3390/FUTURETRANSP5010028