ROUNDABOUT INTERSECTIONS: ANALYSIS FOR SCENARIOS BY MICRO-SIMULATION

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ABSTRACT

In the literature, many analytical techniques allow the study of the performances (Capacity, Levels Of Service, etc) of roundabout intersections: probabilistic methods (HCM, HBS etc.), statistic methods (TRRL, SETRA) etc..

Each method, when formulated, has to consider some aspects of roundabout circulation in comparison to others (geometric elements, vehicular flow and consumer behaviour).

Often, recorded results are not comparable among themselves if all the analytical methods used in the same case study are applied.

An approach that allows a global vision of the problem is today represented by the use of refined simulation analysis software of vehicular circulation.

In this paper the authors introduce the first results of a large survey conducted on an ample range of roundabout scenarios through the application of a modern simulation software. Each scenario describes a fixed roundabout phenomenon using the following variables:

- geometric elements (Inscribed circle radius, Circulatory roadway, Central and Splitter Islands etc.);
- characteristics of the traffic flow (Density, Distribution, Crossing and approach speeds etc.);

The results are presented in terms of level of service offered.

Keywords: roundabout intersection, micro-simulation, capacity and levels of service

1. INTRODUCTION

Many analytical techniques allow the study of the performances (Capacity, Levels of Service, etc) of roundabout intersections: probabilistic methods (HCM, HBS etc.), statistic methods (TRRL, SETRA) etc..

Each method, when formulated, has to consider some aspects of roundabout circulation in comparison to others (geometric elements, vehicular flow and consumer behaviour).

An approach that allows a global vision of the problem is today represented by the use of refined simulation analysis software of vehicular circulation.

2. PERFORMANCES OF ROUNDABOUT INTERSECTIONS

2.1 Fundamental capacity methods

The capacity of each entry is the maximum rate at which vehicles can sensibly be expected to enter the roundabout during a give time under prevailing traffic and geometric features (FHWA 2000).

Many methods applicable to two-way stop-controlled and two-way yield controlled intersection capacity are used as the foundation for the evaluation of roundabout performances. Roundabout analysis models are generally divided into two categories:

- statistical (empirical) models based on the regression of field data;
- analytical (semi-probabilistic) models based instead on the gap-acceptance theory.

Empirical models correlate geometric features and performance measures, such as capacity, average delay and queue length, through the regression of field data. In this way they generate a relationship (generally linear or exponential) between the entering flow of an approach and the circulating flow in front of it (RODEGERDTS L. et al. 2004). These models are better than analytical ones but require a great number of congested, oversaturated conditions, roundabouts for calibration and may have poor transferability to other countries (HCM 2000 – ch. 17 part C).

Gap-acceptance models can be developed instead from uncongested sites: the driver on the approach (entering flow) needs to select an acceptable gap in the circulating stream, to carry out the entering manoeuvre. The gap is the headway between two consecutive vehicles on the circulating flow: so the “critical gap” (t_c) is the minimum headway accepted by a driver in the entering stream. If the gap accepted is larger than minimum, then more than one driver can enter the roundabout: the headway between two consecutive vehicles in the entering flow, which utilize the same gap, is defined as “follow-up time” (t_f). So these analytical models calculate the roundabout capacity as a function of the critical gap, the follow-up time and the circulating flow. However, for capacity evaluation there are some assumptions:

1. constant values for “t_c” and “t_f”;
2. exponential distribution for the gaps into the circulating flow;
3. constant traffic volumes for each traffic flow.

These specific assumptions make the use of these models difficult in practice. Furthermore, there are other limitations, such as:

1. the estimation of the critical gap is not easy;
2. the geometric factors are not directly taken into account;
3. the inconsistent gaps are not accounted for in theory (forced right of way when traffic is congested, circulating drivers give up right of way, different gap accepted by different vehicles, the rejection of large gap before accepting a smaller one, etc.)

A summary of the majority of international methods for the evaluation of roundabout capacity is represented in Table 1a and 1b.

Table 1a Summary of principal international methods for the evaluation of roundabout' performances

COUNTRY	AUTHOR	TYPE	APPLICABILITY	INPUT PARAMETERS
USA	HCM (2000)	Analytical	1 Lane	Circulating flow; critical gap; Follow-up time
	FHWA Roundabout Guide	Statistical	Urban compact 1 Lane	Circulating flow
		Statistical	1 Lane D=30÷40m	Circulating flow
		Statistical	2 Lanes D=55÷60m	Circulating flow
Switzerland	SIMON (1991)	Statistical	1 Lane Bus-Lane	Circulating flow
	LAUSANNE (1991)	Statistical	1 Lane 3 Lanes	Circulating flow; entering flow; conflict length
England	KIMBER (1980)	Statistical	All Types	Circulating flow; flare length; entry width; angle of entry; road width; island diameter.
France	SETRA	Statistical	All Types	Circulating flow; exiting flow; entry width; width of splitter; width of ring.
	LOUAH (1988)	Statistical	All Types	Circulating flow; exiting flow.
	CETUR (1988)	Statistical	1 Lane	Circulating flow
Germany	BRILON (2004)	Analytical	Semi-two-lanes	Circulating flow; no. entry lanes; critical gap; follow-up time.
	WU (1996)	Analytical	Multiple Lanes	Circulating flow; no. entry lanes; no. circulating lanes; critical gap; follow-up time; minimum gap.
	BRILON et al. (1996)	Statistical	1 Lane 3 Lanes	Circulating flow
	BRILON et al. (1993)	Statistical	1 Lane 3 Lanes	Circulating flow
	STUWE (1992)	Statistical	1 Lane 3 Lanes	Circulating flow; no. entry lanes; no. circulating lanes; no. approaches; diameter; travel distance.
Sweden	CAPCAL (1995)	Analytical	1 Lane 2 Lanes	% HV; critical gap; follow-up time; minimum gap; proportion of random arrivals; length of weave area; width of weave area.

Table 1b Summary of principal international methods for the evaluation of roundabout's performances

COUNTRY	AUTHOR	TYPE	APPLICABILITY	INPUT PARAMETERS
Australia	TROUTBECK (1989)	Analytical	1-3 Entry Lanes 1-3 Circulating Lanes	Circulating flow; turning flow; entry flow; no. entry lanes; no. circulating lanes; entry width; diameter; critical gap; follow-up time.
Netherlands	CROW (1999)	Analytical	All Types	Circulating flow; exiting flow on approaches of bicycles…
	CROW et al. (1997)	Analytical	1 Lane	Circulating flow; exiting flow on approaches of bicycles.
	AREM et al. (1992)	Analytical	1 Lane	Circulating flow; exiting flow on approach; critical gap; follow-up time; minimum gap.
Israel	POLUS et al. (1997)	Statistical	1 Lane	No. approaches; no.entry lanes; no. circulating lanes; speed limit.
Austria	FISCHER (1997)	Statistical	1 Lane D=23÷40m	Circulating flow
Finland	LUTTINEN (2004)	Analytical	All Types	Circulating flow; critical gap; follow-up time.

2.2 Micro-simulation software packages

The ever increasing use of roundabouts to solve traffic problems has produced a great number of models which are able to predict operational performances. Each of these methods allows many important roundabout features to be estimated such as capacity, average delay and queue length, by the use of empirical or analytical formulations. In particular the theory of gap-acceptance leads to complex assumptions regarding driver behaviour and often it is not easy to obtain good results. In order to solve this problem there are various software packages that provide roundabout analysis, using several theoretical methods and requiring a variety of input parameters.

However, not many software packages allow the user to model roundabouts exactly. These packages can be divided into two categories: macroscopic and microscopic models. The macroscopic ones, such as SIDRA, Rodel, Arcady, Kreisel, etc., analyze the expected traffic operations at roundabouts by a static analysis: they use traffic volume flows to model intersections as isolated locations. The microscopic ones instead, in particular, simulate the movement of single vehicles, thereby allowing a network-wide analysis.

A summary of the principal international software packages for roundabout feature simulation is shown in table 2a and 2b.

Table 2a Summary of the principal software's for roundabouts simulation

COUNTRY	NAME	TYPE	REFERENCE
U.K.	RODEL	Empirical	STANEK D. et al. (2005)
U.K.	ARCADY	Empirical	MOHAMED A. et al. (2001)
U.K.	PARAMICS	Gap-Acceptance	STANEK D. et al. (2005)
Australia	SIDRA	Gap-Acceptance	SISIOPIKU V. et al. (2001)
Germany	KREISEL	All methods	LEONARDI S. et al. (2005)

Table 2b Summary of the principal softwares for roundabouts simulation

COUNTRY	NAME	TYPE	REFERENCE
Germany	VISSIM	Gap-Acceptance	TRUEBLOOD M. et al. (2004b); KIATTIKOMOL V. et al.(2005)
U.S.A.	HCS/SYNCHRO	Gap-Acceptance	TRUEBLOOD M. et al. (2004a)
U.S.A.	CORSIM	-	V.A. (2000)
U.S.A.	INTEGRATION	-	V.A. (2004)
U.S.A.	SIMTRAFFIC	-	V.A. (2004)
France	GIRABASE	Empirical	LEONARDI S. et al. (2005)
Spain	GETRAM	-	V.A. (2005)

2.3 A microscopic simulation model: VISSIM

The simulation of roundabout traffic operations often presents many complexities, because it is not easy to define all the geometric and user-behavioural features. Vissim gives a flexible platform that allows the user to more realistically model a roundabout. It is based on a link-connector instead of a link-node structure which is easily able to build a complete network or, specifically, a single intersection. It is a microscopic, time-step and behaviour-based simulation model developed to analyze a great number of roadway and public transportation operations. In addition, Vissim is able to import CAD layout (dxf or jpg) and to set it as a background on which links can be drawn. An appropriate scale is assigned, so that all the measurements are in the same units. In this way it allows, for example, all the geometric elements of a roundabout (splitter islands, lane width, number of lanes, entry width, etc.) to be precisely drawn. Anyway, there are three principal features which are very important to set in order for a correct simulation: 1) driver behaviour; 2) approach speed, reduced speed zones and circulatory speed; 3) priority rules; and finally, 4) dynamic traffic assignment.

2.3.1 Driver behaviour

The traffic flow model used by Vissim is a discrete, stochastic, time-step-based microscopic model with driver-vehicle-units as single entities. The model contains a psycho-physical car following model and a rule-based algorithm for lateral movements realized by Wiedemann at the University of Karlsruhe during the early 1970s. This model takes into account four driving modes which are correlated to combinations of speed difference and distance between two vehicles, as is shown in Figure 1:

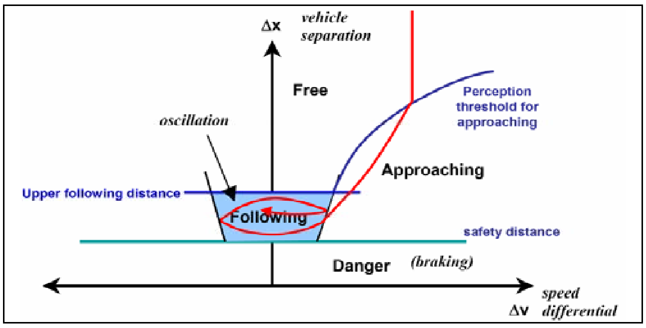


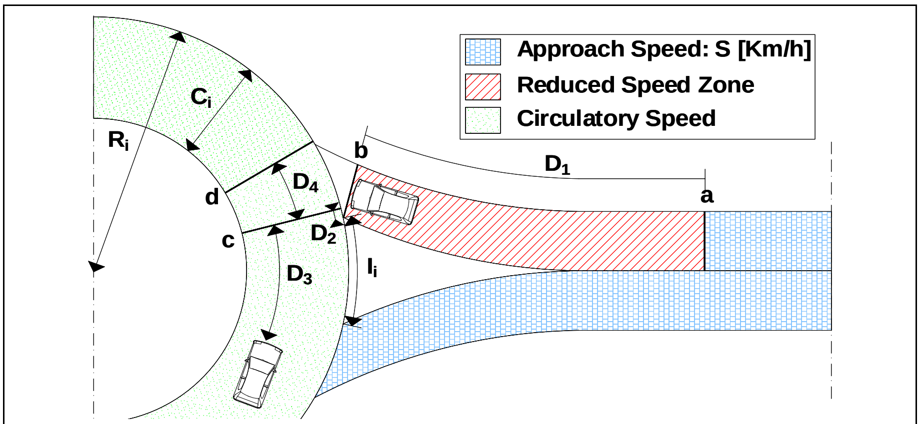
Figure 1 User-behavioural model used by Vissim

- free driving mode: the vehicle is not influenced by preceding vehicles and maintain his desired speed;
- approaching mode: the vehicle adapts his speed to the lower one of a preceding vehicle by a deceleration that finishes when the speed difference between the vehicles is zero;
- following mode: the vehicle follows the preceding one without any acceleration or deceleration;
- braking mode: the vehicle makes a medium-high deceleration because the separation between vehicles is lower than the desired safety distance.

So each mode presents an acceleration which is the result of speed, speed difference, distance and the individual driver and vehicle characteristics.

2.3.2 Approach speed, circulatory speed and reduced speed zones

An accurate definition of the vehicle speeds is very important to realize a good simulation of a roundabout.



a=*Start of reduced speed zone;* **b**=*Stop line/End of reduced speed zone;*
c=*Conflict marker 1;* **d**=*Conflict marker 2;*
$\mathbf{D_1}$=*Length of reduced speed zone* (a_{max} *= 2 m/sec*^{2}*);* $\mathbf{D_2}$=*Distance of* **c** *from the splitter island;*
$\mathbf{D_3}$=*Relevant time gap and headway;* $\mathbf{D_4}$=*Distance between the conflict markers;*
$\mathbf{R_i}$=*Inscribed circle radius;* $\mathbf{C_i}$=*Circulating roadway width;* $\mathbf{I_i}$=*Splitter island width.*

Figure 2 Description of the principal parameters used in Vissim for circulation rules

Vissim allows the definition of the desired speed of every type of vehicle when the said vehicle enters the network. The approach speed of every leg of the roundabout is taken in a range defined by an empirical speed curve which is created by the user: this curve usually presents an S-form (normal distribution). The vehicles maintain the desired speed until traffic conditions or geometric features require them to change it. Vissim uses reduced speed zones in order to change the desired speed: these have been used to set the influence of roundabout entry geometry on the approach speed. Their length $\mathbf{D_1}$ is directly correlated to the approach speed of each leg by a linear relation generally based on field data. The reduced speed zones assign a new speed distribution to the vehicles which begin to decelerate before the start of the same areas. After the end of these zones the vehicles begin to accelerate in order to reach the previous desired speed if the user does not set a new one. Specifically, for roundabouts, after the reduced speed area of the entry, a Circulatory Speed distribution is set which is derived from vehicle radial dynamics equilibrium:

$$V = \sqrt{127 \cdot R \cdot (q + f_t)} \quad \text{(Eq. 1)}$$

With these assumptions: $q=0$; $f_t=0.23$; $R=R_i-(C_i/2)$.

This equation allows the average speed (V_m) to be obtained of the circulating vehicles into the roundabout and the range of the circulatory speed distribution to be set. In fact, considering this as a normal distribution and considering standard deviation σ=5Km/h (this is derived from field data), it is therefore possible to define the extreme values of the range as $V_m \pm (1{,}96 \cdot \sigma)$ in order to consider the 95th percentile of the circulatory speed.

2.3.3 Priority rules

The most important aspect to modelling a roundabout in Vissim is to correctly define the priority rules for entering and exiting movements (for a one-lane-roundabout there are only priority rules for entering vehicles). These rules are based on two fundamental parameters: minimum gap time and minimum headway, see Figure 2.

A vehicle, which is standing at the stop-line, enters the circulatory roadway only when the time gap and headway $\mathbf{D_3}$ measured from the conflict markers are greater than the relative minimum values. A priority rule is usually composed of a stop line (**b**) and one or more conflict markers, **c** and **d** in this case.

In particular, **c**, placed distance $\mathbf{D_2}$ over the right corner of the splitter island, is used to set the minimum gap time and the minimum headway for normal traffic conditions; while **d** placed distance $\mathbf{D_4}$ over the conflict marker 1 (**c**), is used to define only the minimum headway for congested conditions. It is possible to set different values of critical gap or headway for any type of vehicle, but in this case only traffic flows measured in "equivalent vehicles per hour" are considered. So both marker conditions must be satisfied for a vehicle to enter the roundabout.

2.3.4 Dynamic traffic assignment

One of the most important features within Vissim is the dynamic traffic assignment. This module allows the user-behaviour to be set for routing decisions, so the input data only becomes an O/D matrix. This contains the number of movements for each origin/destination during a specific interval. In addition, Vissim can define different matrices for different kinds of vehicles and for different intervals.

3. EXPERIMENTAL PLANNING

The study proposed in this paper was conducted through the use of the VISSIM micro-simulator.

The imposed inputs are pointed out in synthesis below (see table 3 concerning values):

- distribution and assignment of traffic flow in time and space;
- implementation of circulation rules: approach speed, reduced speed zones, circulatory speed zones and priority rules;

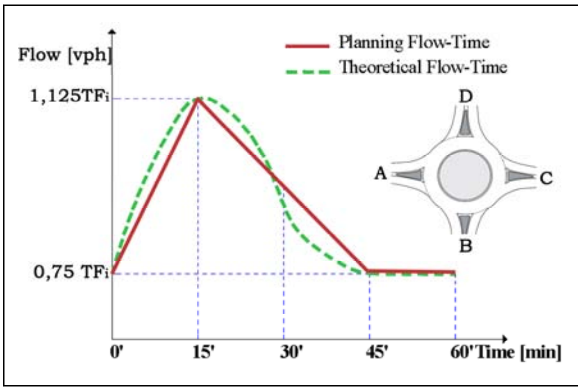
- setting up of scenarios to be analyzed (choice of geometric and traffic variables);

recorded outputs are represented by the average stop-line delay.

3.1 Distribution and assignment of traffic flow

In the experimental planning introduced in this paper, four separate traffic flows TF_i (with i=1,…,4 - only motorcars) are considered, see table 4. The traffic flows have been distributed in the time and in the space as shown in figure 3:

- the flow-time curve of traffic demand was obtained in accordance with a theoretical curve (CAPILUPPI 2000);
- the O/D matrixes used have a balanced traffic flow distribution.



	A	B	C	D
A	-	1/8	6/8	1/8
B	1/8	-	1/8	6/8
C	6/8	1/8	-	1/8
D	1/8	6/8	1/8	-

(light shading)	Turn on the right
(medium shading)	Turn on the left
(dark shading)	Crossing

Figure 3 Theoretical curve of traffic and planning demand used in the micro-simulation; O/D matrix used for traffic flow distribution.

3.2 Circulation rules

In this paper, in regard to circulation rules the values used are shown in table 3.

Table 3 Values used for circulation rules

D_1	$D_{1i} = 1{,}29 \cdot S_{i\ average} + 11{,}43$ ($S_{i\ average}$ = Approach speed with i=1,2,3 - estimated from FHWA 2000)		
D_2	0,5m		
D_3	If circulatory speed is ⇒	15÷50km/h ⇓	≤ 15km/h ⇓
		Conflict Marker **c**	Conflict Marker **d**
	Time Gap	3sec	0sec
	Headway	5m	5m
D_4	4m		

3.3 Setting up of scenarios

Three separate sets of scenarios for single-lane roundabouts were composed and analyzed, see figure 4 and table 4, in total, 144 scenarios:

- <u>R-Scenarios</u>. They have the following variables: Traffic Flow (TF_i), approach Speed (S_i), inscribed circle Radius (R_i);
- <u>I-Scenarios</u>. They have the following variables: Traffic Flow (TF_i), approach Speed (S_i), splitter Island width (I_i);
- <u>C-Scenarios</u>. They have the following variables: Traffic Flow (TF_i), approach Speed (S_i), Circulating roadway width (C_i).

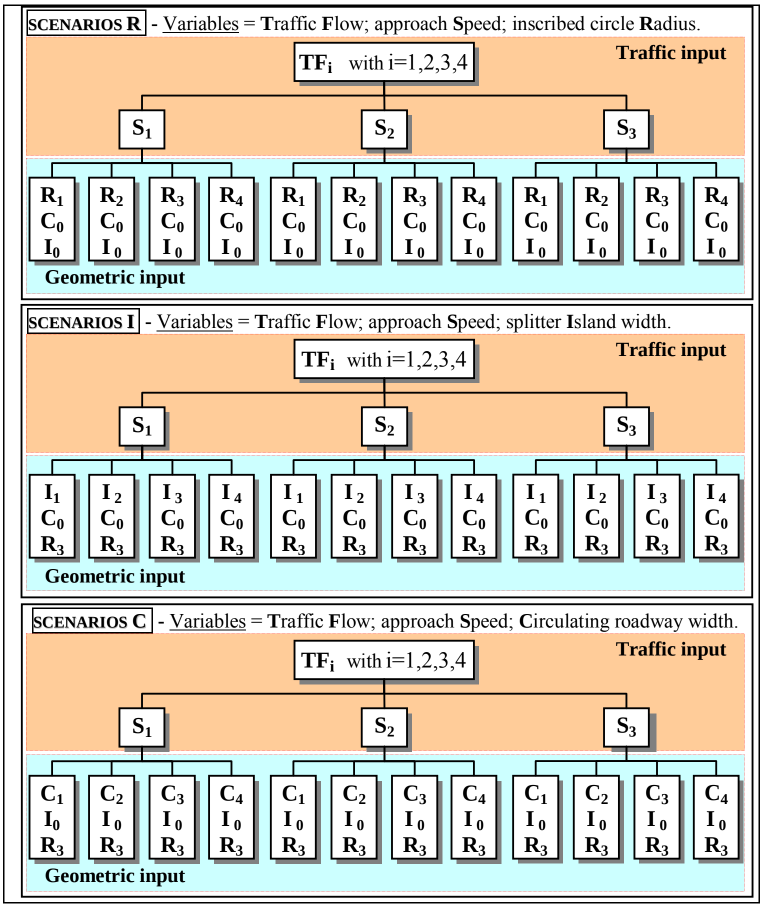


Figure 4 Sets of scenarios analyzed

Table 4 Summary of the imposed values to inputs data

PARAMETERS	INPUT DATA
Traffic Flow	TF_1=350vph; TF_2=500vph; TF_3=600vph; TF_4=650vph.
Approach Speed	S_1=30÷40km/h; S_2=40÷50km/h; S_3=50÷60km/h.
Inscribed Circle Radius	R_1=15m; R_2=20m; R_3=25m; R_4=30m.
Splitter Island Width	I_0=6m; I_1=8m; I_2=10m; I_3=12m; I_4=14m.
Circulating Roadway Width	C_0=6m; C_1=7m; C_2=8m; C_3=9m; C_4=10m (only single-lane).

4. EXPERIMENTAL RESULTS

Vissim, as all micro-simulation software program, simulates traffic in a *one-shot* simulation; therefore, for to get a statistically valid estimate of stop-line delays, n° 3 simulations were made for each sets of scenarios (multiple-run simulations with running time of one hour for each simulation).

In tables 5, 6 and 7 are introduced the results obtained by the micro-simulations for each sets of scenarios analyzed in terms of average stop-line delays. This average values are calculated for multiple-run simulations and on all legs of each roundabout.

Table 5 Stop-line delay (seconds) for R-Scenarios

	TF_1 = 350vph			TF_2 = 500vph			TF_3 = 600vph			TF_4 = 650vph		
	Approach Speed											
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
R_1	2,8	2,8	2,8	10,8	11,0	11,5	30,3	34,4	37,5	68,6	69,4	71,7
R_2	2,9	2,8	2,9	9,9	9,7	11,5	26,6	30,3	32,8	58,5	63,5	62,3
R_3	2,8	2,8	3,1	9,5	9,0	11,2	26,6	27,5	31,1	60,0	60,0	61,3
R_4	2,5	2,3	2,4	7,5	8,5	8,3	17,1	18,3	22,8	42,1	43,8	44,1

Table 6 Stop-line delay (seconds) for I-Scenarios

	TF_1 = 350vph			TF_2 = 500vph			TF_3 = 600vph			TF_4 = 650vph		
	Approach Speed											
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
I_0	2,8	2,8	3,1	9,5	10,5	11,4	26,6	27,5	31,1	60,0	60,0	33,8
I_1	2,7	2,3	2,5	8,2	8,7	9,5	18,1	16,8	18,3	37,6	39,5	25,5
I_2	2,4	2,3	2,5	8,5	8,5	8,3	16,0	15,7	15,0	29,5	36,1	19,7
I_3	2,2	2,1	2,1	7,3	7,4	8,1	12,1	11,9	13,2	21,2	21,8	18,2
I_4	2,1	1,9	2,1	7,1	6,9	7,6	11,7	11,5	11,3	20,6	19,6	11,5

Table 7 Stop-line delay (seconds) for C-Scenarios

	TF_1 = 350vph			TF_2 = 500vph			TF_3 = 600vph			TF_4 = 650vph		
	Approach Speed											
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
C_0	2,8	2,8	3,1	9,5	10,5	11,4	26,6	27,5	31,1	60,0	60,0	61,3
C_1	2,6	2,5	2,8	9,0	9,5	9,5	23,8	25,6	26,2	54,0	53,2	56,1
C_2	2,3	2,5	2,5	8,4	8,7	9,4	19,2	17,8	18,2	39,9	44,6	40,3
C_3	2,6	2,5	2,6	8,7	8,0	8,9	19,4	21,0	21,5	40,1	40,8	41,0
C_4	2,4	2,4	2,6	8,6	8,8	9,0	17,5	19,5	20,3	36,5	46,4	46,2

5. DATA ANALISYS

The results obtained by studying different roundabout configurations were analyzed in terms of level of service.

The levels of service were calculated in accordance with HCM2000, see table 8.

Table 8 Level of service for unsignalized intersection (HCM2000)

LOS		STOP-LINE DELAY (sec/veh)
A		≤ 10
B		10÷15
C		15÷25
D		25÷35
E		35÷50
F		> 50

5.1 R - Scenarios

The R-scenarios are characterized by following geometric variable: inscribed circle Radius (R_i). In figure 5 are represented the levels of service in terms of Traffic Flow (TF_i) and approach Speed (S_i), too.

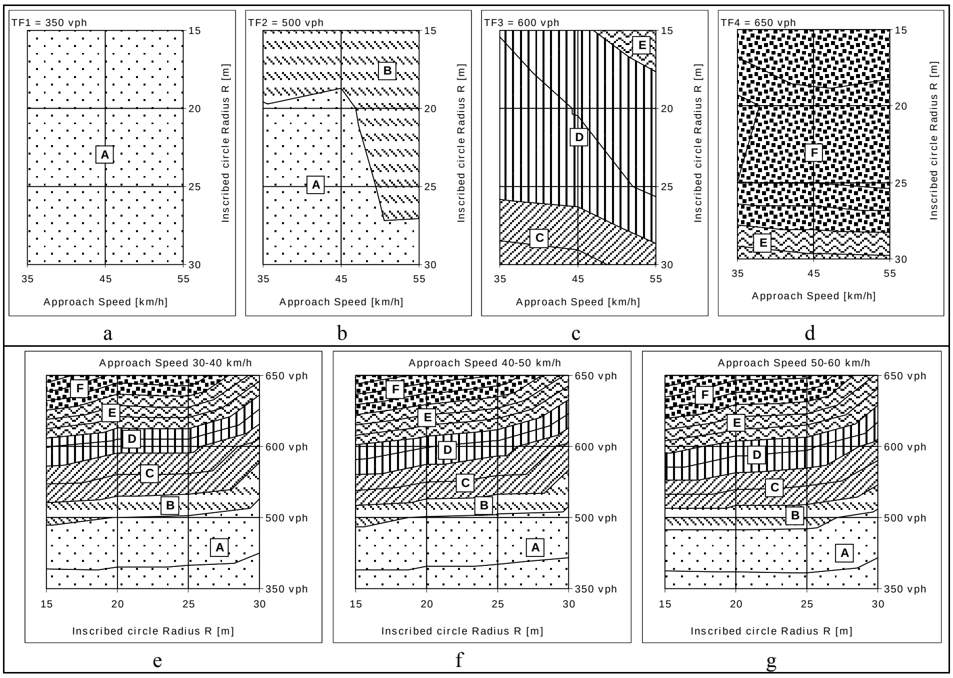


Figure 5 Levels of service for R-Scenarios

By the analysis of figure 5(a-b-c-d) it is possible to affirm that:

- for TF_1 the level of service is always equal to A for each R-scenarios;
- for each TF_i (with i=2,3,4) and for each S_i (with i=1,2,3), if radius R_i (with i=1,2,3,4) increases the level of service improves (F →A);
- the approach speed (S_i) influences the level of service in no-saturation condition (TF_i with i=1,2,3). The approach speed influence is probably connected to the length of the reduced speed zones (D_l) and to circulatory

speed. In fact, D_1 is directly proportional to approach speed, while circulatory speed depended on the variability of R_i (Eq. 1).

Furthermore, by the analysis of figure 5(e-f-g) for each approach speed range S_i (with i=1,2,3) is possible to say that all the levels of service are present (A÷F).

5.2 I - Scenarios

The I-scenarios are characterized by following geometric variable: splitter Island width (I_i). In figures 6 are represented the levels of service in terms of Traffic Flow (TF_i) and approach Speed (S_i), too.

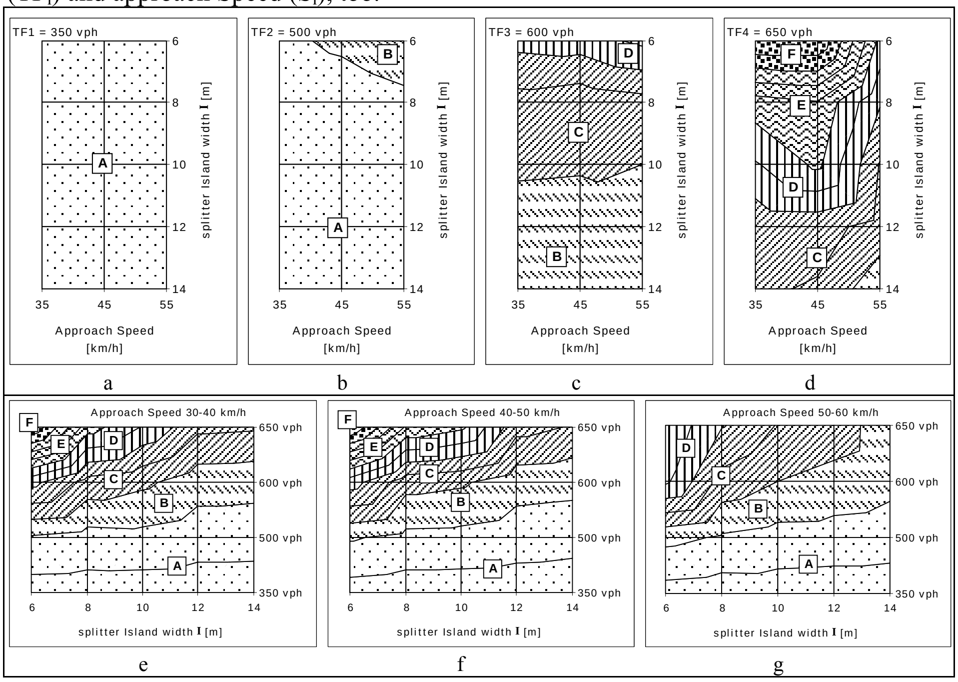


Figure 6 Levels of service for I-Scenarios

By the analysis of figure 6(a-b-c-d) is possible to affirm that:

- for TF_1 the level of service is always equal to A for each I-scenarios;
- for each TF_i (with i= 2,3,4) and for each S_i (with i=1,2,3), if splitter Island width (I_i) (with i=0,1,2,3,4) increases the level of service improves (F →A);
- specifically, for TF_3 splitter island width I_2= 10m represents a passage from B to C level of service for each S_i (with i=1,2,3);

Furthermore, by the analysis of figure 6(e-f) is possible to say that while for approach speed range S_i with i=1,2 all the levels of service are present (A÷F); if approach speed is equal to S_3 (maximum value), see figure 6g, only A÷D levels of service are present.

5.3 C - Scenarios

The C-scenarios are characterized by following geometric variable: circulating roadway width (C_i). In figures 7 are represented the levels of service in terms of traffic flow (TF_i) and approach speed (S_i), too.

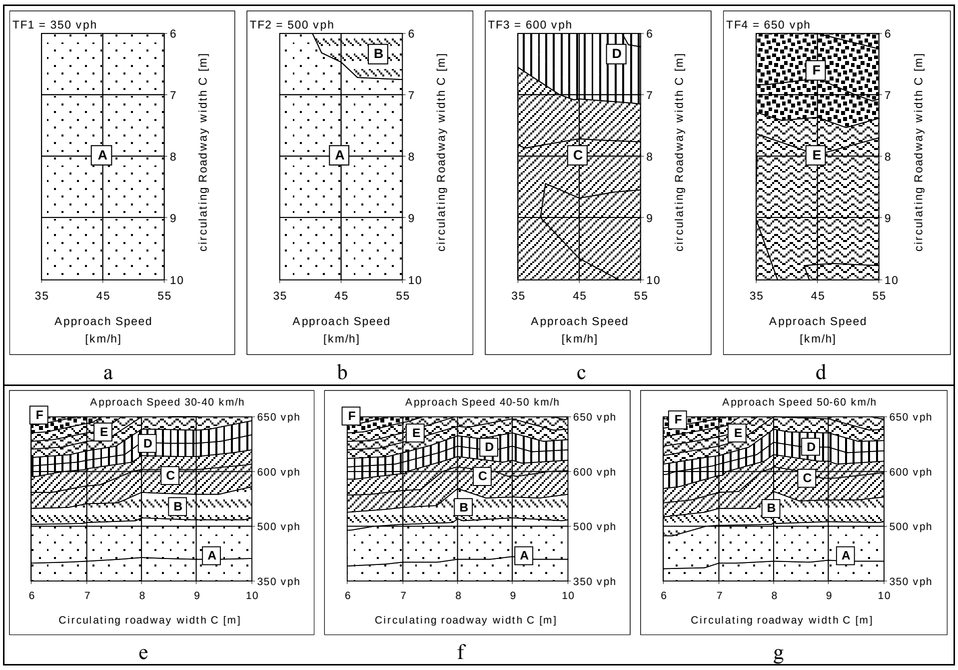


Figure 7 Levels of service for C-Scenarios

By the analysis of figure 7 (a-b-c-d) is possible to affirm that:

- again, for TF_1 the level of service is always equal to A for each C-scenarios;
- for each TF_i (with i= 2,3,4) and for each S_i (with i=1,2,3), if circulating roadway width (C_i) (with i=0,1,2,3,4) increases the level of service improves (F →A);
- In particular, for TF_3 (see figure 4c) circulating roadway width $C_l \approx$ 7m represents a passage from C to D level of service for each S_i (with i=1,2,3); while for TF_4 (see figure 4d) circulating roadway width $C_l \approx$7,5m represents a passage from E to F level of service for each S_i (with i=1,2,3). It is opportune to remember that in this paper the VISSIM implementation considers a circulating roadway to single-lane; therefore circulating roadway width $C_i \approx$7,25m probably represents a threshold.

Furthermore, by the analysis of figure 7(e-f-g) for each approach speed range S_i (with i=1,2,3) is possible to say that all the levels of service are present (A÷F).

6. CONCLUSIONS

In this paper three different sets of scenarios for single-lane roundabouts were analyzed by a micro-simulator: R-scenarios, I-scenarios C-scenarios. Inscribed circle radius, splitter island width and circulating roadway width respectively represented the variables of each scenarios, while traffic flow and approach speed was imposed as parametric variables for every scenario. In total, 144 scenarios were analyzed.

The interpretation of results by levels of service has allowed interesting correlations to be obtained between stop-line delay and the aforesaid geometric variables. These reading results have allowed a first cataloguing of some scenarios.

In the future, new scenarios will be studied using simulation, in order to build a complete cataloguing of roundabout configurations in terms of levels of service, considering for example: different O/D matrixes distribution; non-symmetrical roundabout configurations; different priority rules.

Finally, the comparison among micro-simulation data, analytical methods and data field is important, in fact this control also allows a best setting of the micro-simulator inputs. Recently, in this direction the Authors proposed the first interesting results (GALLELLI. V. et al. 2007).

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