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**PASSENGER CAR EQUIVALENT FACTORS
FOR HEAVY VEHICLES ON TURBO ROUNDABOUTS
– A CASE STUDY FROM POLAND**



**RESEARCH
UNIVERSITY**

EXCELLENCE INITIATIVE

Ministry of Science
and Higher Education

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THE PURPOSE OF RESEARCH

For the purpose of passenger car equivalent factors evaluation, the impact of heavy vehicles on the three headway parameters like:

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- follow-up times (t_f),
- critical gaps (t_g), and
- time gaps between the vehicles moving on turbo roundabouts circulatory roadways (t_p)

were examined.



THEORETICAL MODELS USED FOR PASSENGER CAR EQUIVALENT FACTORS CALCULATION

Model No	Theoretical model basis	Assumed measures for traffic conditions
I	The comparison of two traffic streams (passenger and mixed traffic streams) under similar road traffic conditions	Average travel time for the vehicles in the traffic stream
II		Average vehicles travel speed or momentary speed
III		85 % quintile of the vehicles speed in the traffic stream
IV		Maximum traffic volume (capacity)
V		Total travel time of all vehicles in the traffic stream
VI		Average speed
VII 3	The comparison of densities of two traffic streams (passenger and mixed traffic streams) under similar road traffic conditions	Maximum traffic volume or maximum density
VIII	The comparison of average time differences or distances between the vehicles in two homogeneous streams (passenger car stream and analysed vehicle type stream) under similar traffic conditions	Average travel time or average vehicles travel speed in traffic flow
IX		Maximum traffic volume - capacity (Webster & Greenshields model)
X	The comparison of some characteristics related to overtaking in the traffic stream for two vehicles: passenger car and vehicle from analysed group	Average number of vehicles overtakings
XI		The average delay caused vehicles overtaking in the traffic stream

Source: Szczuraszek, T. (1999). Analiza modeli stosowanych do przeliczania pojazdów rzeczywistych na pojazdy umowne. Zeszyty Naukowe Nr 223 Budownictwo 31, 83-98.



PASSENGER CAR EQUIVALENT FACTORS VALUES ACCORDING TO POLISH GUIDELINES

Vehicle type	Denotation	Intersection type		
		Intersections without traffic lights	Roundabouts	Intersections with traffic lights
Passenger cars and passenger vans	E_{SOD}	1.0	1.0	1.0
Trucks and buses	E_{SC}	1.7	1.7	2.0
Trucks with trailers, articulated buses	E_{SCP}	2.5	2.5	2.0
Motor bikes and bicycles	$E_{M/R}$	0.5	0.5	0.3

Source:

1. Chodur, J. (2004). *Metoda obliczania przepustowości skrzyżowań bez sygnalizacji świetlnej. Instrukcja obliczania.* Waraw. Generalna Dyrekcja Dróg Krajowych i Autostrad.
2. Tracz, M. et al. (2004a). *Metoda obliczania przepustowości skrzyżowań z sygnalizacją świetlną. Instrukcja obliczania.* Warszawa. Generalna Dyrekcja Dróg Krajowych i Autostrad.
3. Tracz, M. et al. (2004b). *Metoda obliczania przepustowości rond. Instrukcja obliczania.* Warszawa. Generalna Dyrekcja Dróg Krajowych i Autostrad.

The vehicles conversion coefficient into passenger cars:

$$f_c = \frac{1}{1 + u_{SC}(E_{SC} - 1) + u_{SCP}(E_{SCP} - 1) + u_{M/R}(E_{M/R} - 1)} \quad [-]$$

where:

- f_c - conversion coefficient of real vehicles into passenger cars [-],
- $usc, uscp, um/r$ - the shares of particular types of vehicles in the traffic stream [-],
- sc - trucks and buses,
- scp - trucks with trailers, articulated buses,
- m/r - motor bikes and bicycles,
- $ESC, ESCP, EM/R$ - passenger car equivalent factors according to the Table 3.



RESEARCH AREA

- 23 turbo roundabouts localized in Poland
- All turbo roundabouts have had four entries and different geometry
- All measurements were taken in good weather conditions (no atmospheric precipitation)
- The share of heavy vehicles didn't exceed 22.0 %

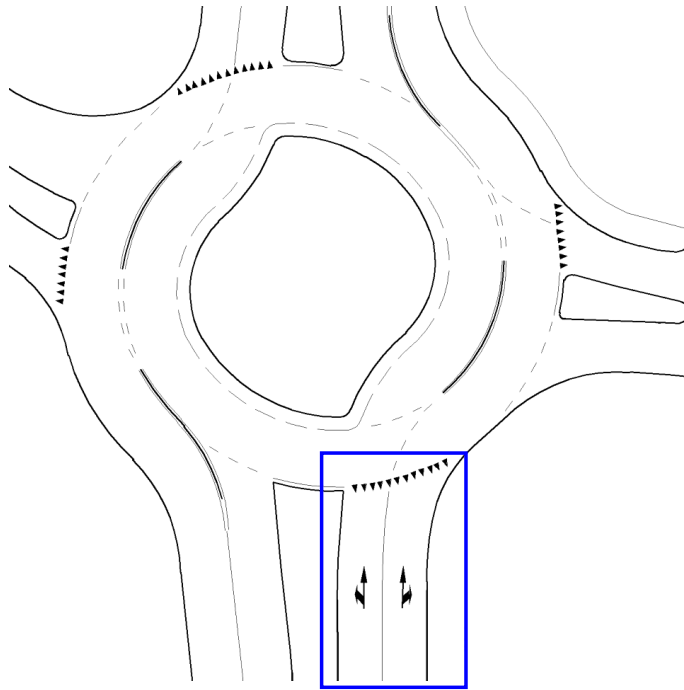
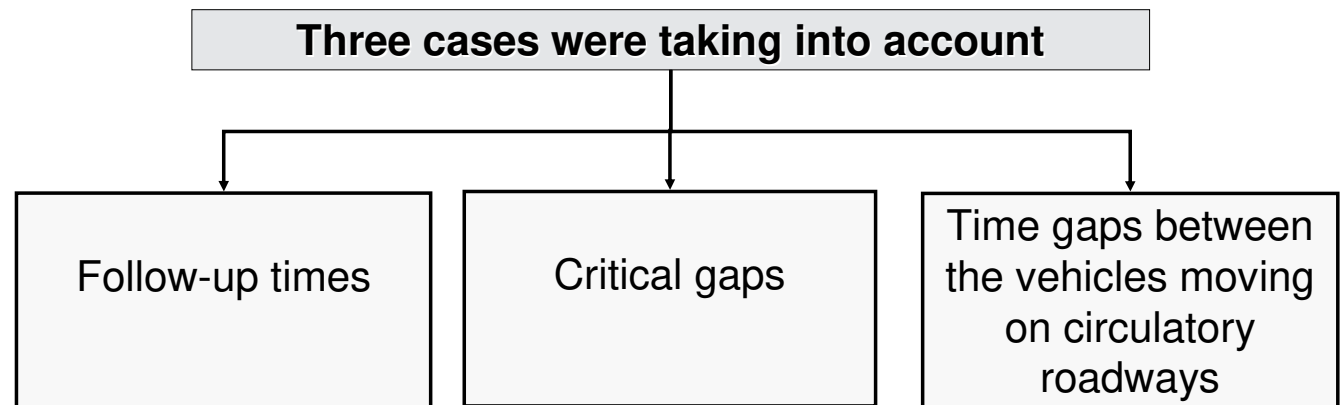
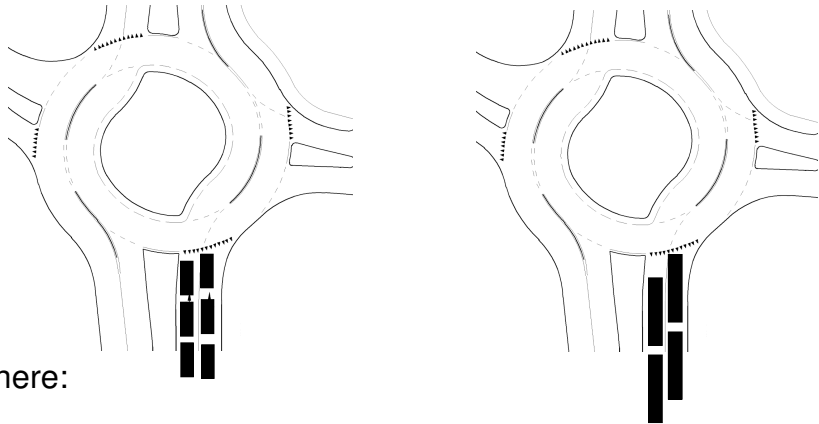


Fig. Traffic control scheme for turbo roundabout entry at which measurements were made



PCE FACTORS FOR FOLLOW-UP TIMES

The situations taken into account in measurements



where:

- passenger car
- heavy vehicle, i.e.: trucks, buses as a first group, and trucks with trailers and articulated buses as a second group

$$E_f = \frac{t_{f-SC}}{t_{f-SOD}} [-] \quad \text{and} \quad E_f = \frac{t_{f-SCP}}{t_{f-SOD}} [-]$$

where:

- E_f - passenger car equivalent factor for heavy vehicles [-]
- t_{f-SC} - the follow-up time between such heavy vehicles as trucks, and buses [s]
- t_{f-SCP} - the follow-up time between such heavy vehicles as trucks with trailers, and articulated buses [s]
- t_{f-SOD} - the follow-up time between passenger cars [s]

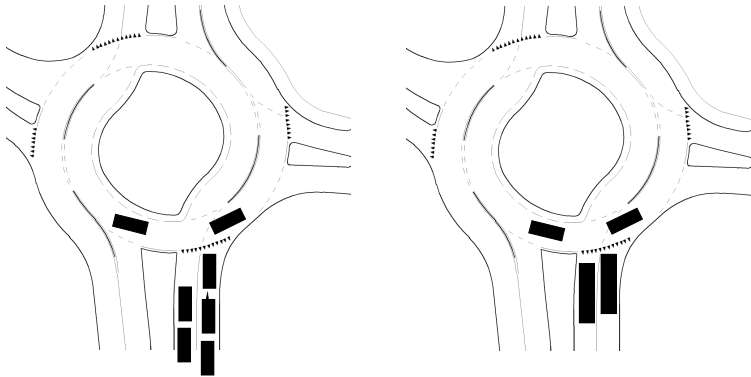
PCE FOR FOLLOW-UP TIMES BETWEEN THE VEHICLES ENTERING ON THE CIRCULATORY ROADWAY FROM THE TURBO ROUNDABOUT ENTRY LANES



Entry lane	Sample size (n)	$\overline{t_{f-SC}}$ [s]	$\overline{t_{f-SCP}}$ [s]	$\overline{t_{f-SOD}}$ [s]	E_{f-SC} [-]	E_{f-SCP} [-]
Left	158	3.22	3.53	1.91	1.68	1.84
Right	411	3.62	3.96	2.12	1.71	1.86
Average values					1.69	1.85

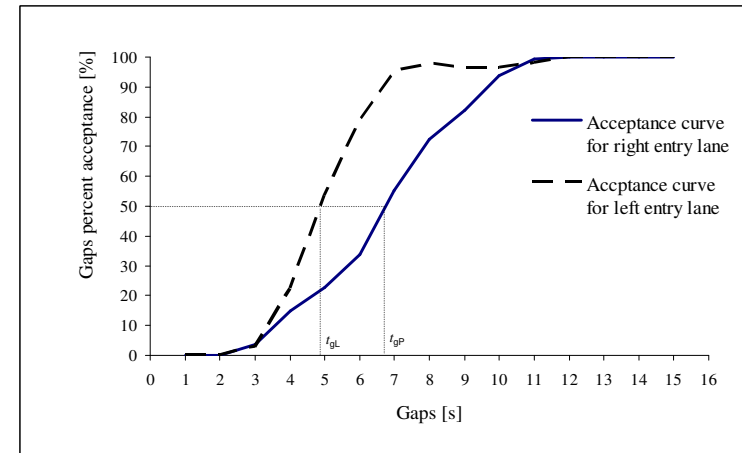
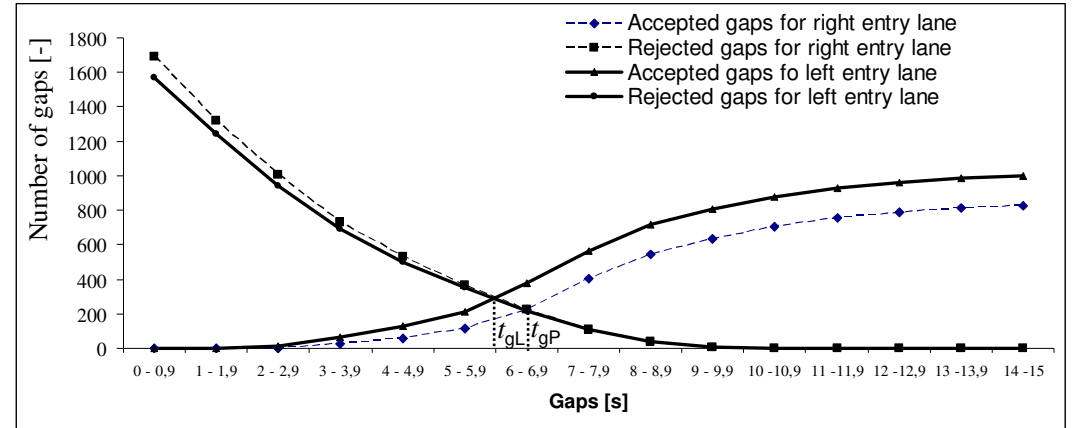


PCE FACTORS FOR CRITICAL GAPS

The situations taken into account in measurements

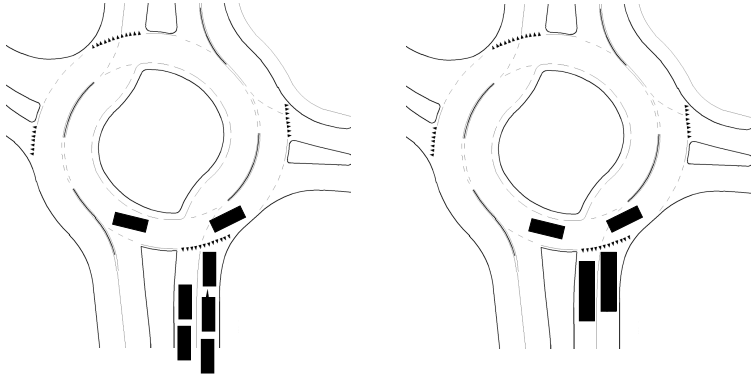


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where:
-  - passenger car
 -  - heavy vehicle, i.e.: trucks, buses, trucks with trailers, articulated buses



PCE FACTORS FOR CRITICAL GAPS

The situations taken into account in measurements



where:

- passenger car
- heavy vehicle, i.e.: trucks, buses, trucks with trailers, articulated buses

$$E_g = \frac{t_{g-SC}}{t_{g-SOD}} [-] \quad \text{and} \quad E_g = \frac{t_{g-SCP}}{t_{g-SOD}} [-]$$

where:

- E_g - passenger car equivalent factor for heavy vehicles [-]
- t_{g-SC} - the critical gap for heavy vehicles, i.e.: trucks, buses [s]
- t_{g-SCP} - the critical gap for heavy vehicles, i.e.: trucks with trailers, articulated buses [s]
- t_{g-SOD} - the critical gap for passenger cars [s]

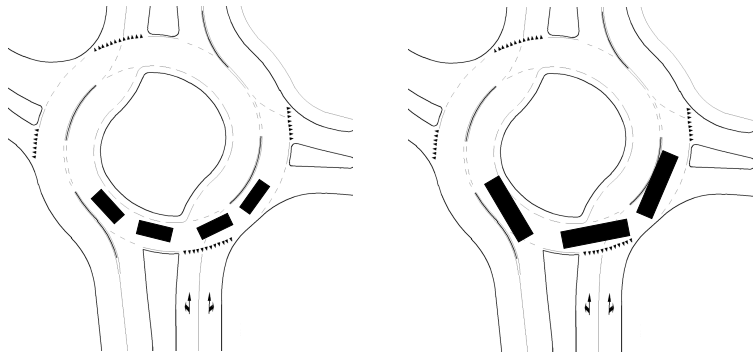
PCE FACTORS FOR CRITICAL GAPS FOR VEHICLE DRIVERS ON TURBO ROUNDABOUT ENTRY LANES

Entry lane	Sample size (<i>n</i>)	$\overline{t_{g-SC}}$ [s]	$\overline{t_{g-SCP}}$ [s]	$\overline{t_{g-SOD}}$ [s]	E_{g-SC} [-]	E_{g-SCP} [-]
Left	479	6.19	6.37	3.60	1.72	1.76
Right	511	7.83	8.46	4.48	1.74	1.88
Average values					1.73	1.82





PCE FACTORS FOR THE TIME GAPS BETWEEN VEHICLES MOVING ON THE CIRCULATORY ROADWAY

The situations taken into account in measurements



where:

-  - passenger car
-  - heavy vehicle, i.e.: trucks, buses, trucks with trailers, articulated buses

$$E_p = \frac{t_{p-SC}}{t_{p-SOD}} [-] \quad \text{and} \quad E_p = \frac{t_{p-SCP}}{t_{p-SOD}} [-]$$

where:

- E_p - passenger car equivalent factor for heavy vehicles [-]
- t_{p-SC} - the critical gap for heavy vehicles, i.e.: trucks, buses [s]
- t_{p-SCP} - the critical gap for heavy vehicles, i.e.: trucks with trailers, articulated buses [s]
- t_{p-SOD} - the critical gap for passenger cars [s]

PCE FACTORS FOR THE TIME GAPS BETWEEN VEHICLES MOVING ON THE CIRCULATORY ROADWAYS OF TURBO ROUNDABOUTS

Entry lane	Sample size (<i>n</i>)	$\overline{t_{p-SC}}$ [s]	$\overline{t_{p-SCP}}$ [s]	$\overline{t_{p-SOD}}$ [s]	E_{p-SC} [-]	E_{p-SCP} [-]
Left	382	3.69	3.96	2.11	1.74	1.87
Right	614	4.33	4.56	2.32	1.86	1.96
Average values					1.80	1.91



PASSENGER CAR EQUIVALENT FACTORS VALUES FOR TURBO ROUNDABOUTS

Vehicle type	Denotation	Left entry lane	Right entry lane	Entry
Passenger cars	E_{SOD}	1.00	1.00	1.00
Trucks and buses	E_{SC}	1.71	1.77	1.74
Trucks with trailers, articulated buses	E_{SCP}	1.82	1.90	1.86

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CONCLUSIONS

- All headway parameters which include heavy vehicles are longer than those under the condition of passenger cars only
- The increasing tendency of heavy vehicles in traffic stream implied that headway parameters become longer with the increase of heavy vehicle percentage
- The passenger car equivalent factor on turbo roundabouts **for trucks and buses** (E_{sc}) is equal:
 - 1.74 for entry,
 - 1.71 for left entry lane,
 - 1.77 for right entry lane.
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- The passenger car equivalent factor for **trucks with trailers and articulated buses** (E_{scpl}) is equal:
 - 1.86 for entry,
 - 1.82 for left entry lane,
 - 1.90 for right entry lane.



THANK YOU
VERY MUCH
FOR YOUR ATTENTION



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