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ROUNDABOUTS

Country report - Poland

Progress in areas of capacity and geometric design

- New geometrical forms of small roundabouts
- Bypasses of small roundabouts
- Signalized roundabouts
- Capacity of bypass merging area
- Impacts of non-stationarity on performance of roundabout entries

Roundabouts; guidelines, conferences

- **Polish guidelines**:

  1996 - first, 2001 second, demand for updating 2012 – next?

  Guidelines are obligatory only for national roads for other roads – it is only technical knowledge

  2010 April – **National Roundabout Conference** organized in Krakow – 24 papers, 220 participants with invited speakers (G, NL, S, Lt)

Roundabouts, Rotary intersections

After a 20 years since construction of the first new type roundabouts , several studies reported very high efficiency of small one-lane roundabouts regarding road safety and capacity, much worse safety of the two-lane roundabouts.

One-lane roundabouts are on average about 3 times safer than priority intersections and at least 2,5 X safer than signalised intersections (layout before) with regard to the number of accidents and even much more regarding their victims. Fatal accidents **almost do not happen.**

Small one-lane roundabouts
Safe, Efficient, Aesthetic,

Specific problems in roundabout design in Poland

- Increasing capacity of one-lane roundabout - using bypass for right turns
- Passes for extra-long and wide vehicles
- Locating of roundabout at railway crossings
- Tram line through small roundabout

Other issues

- Use of mini-roundabouts
- Cycle traffic through roundabouts
- Interchanges with roundabouts (diamond)

New geometrical forms of small roundabouts

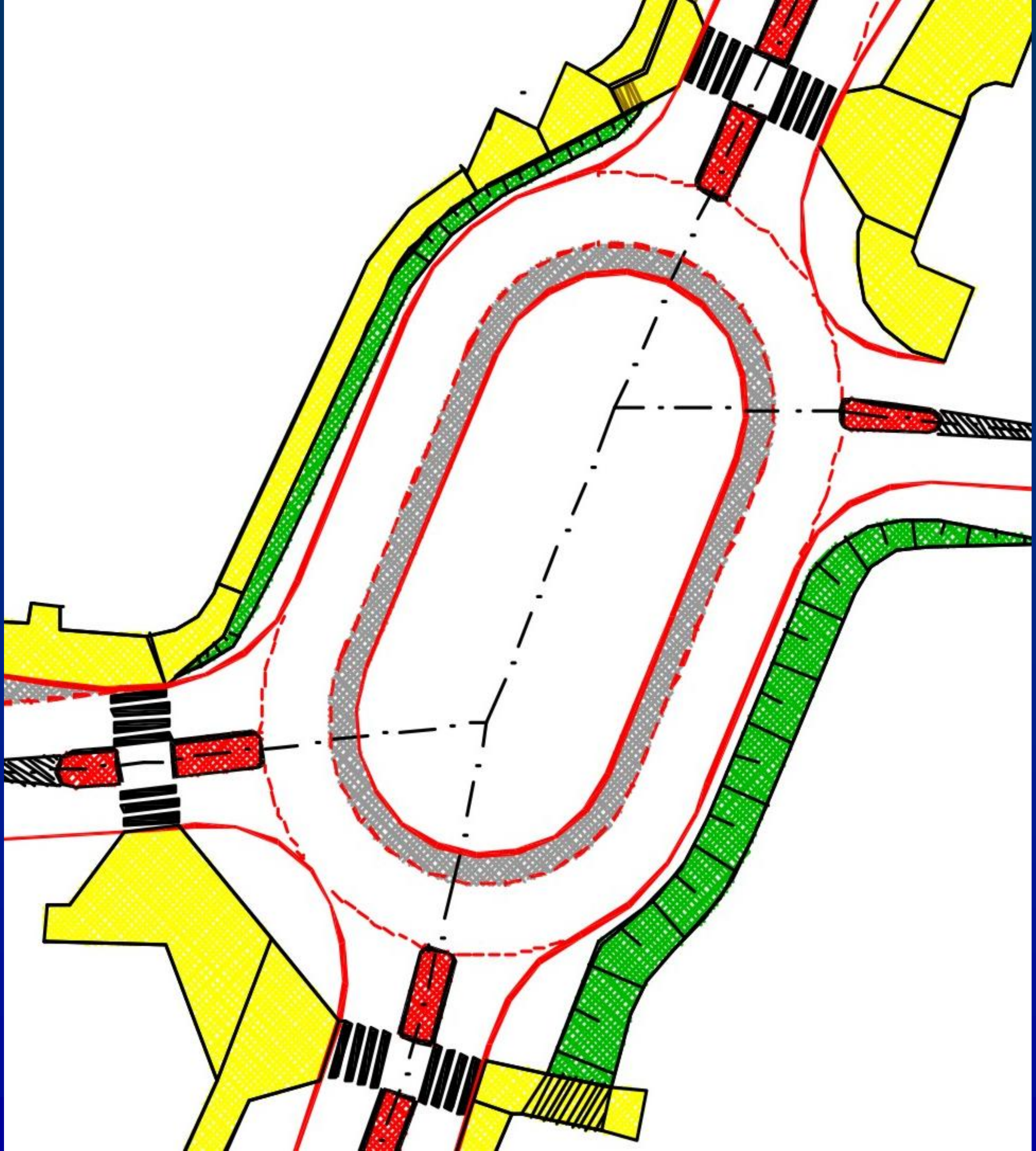
Various new, constructed recently individually, more or less sensible designs, which should meet traffic volume, traffic composition and traffic safety requirements, include:

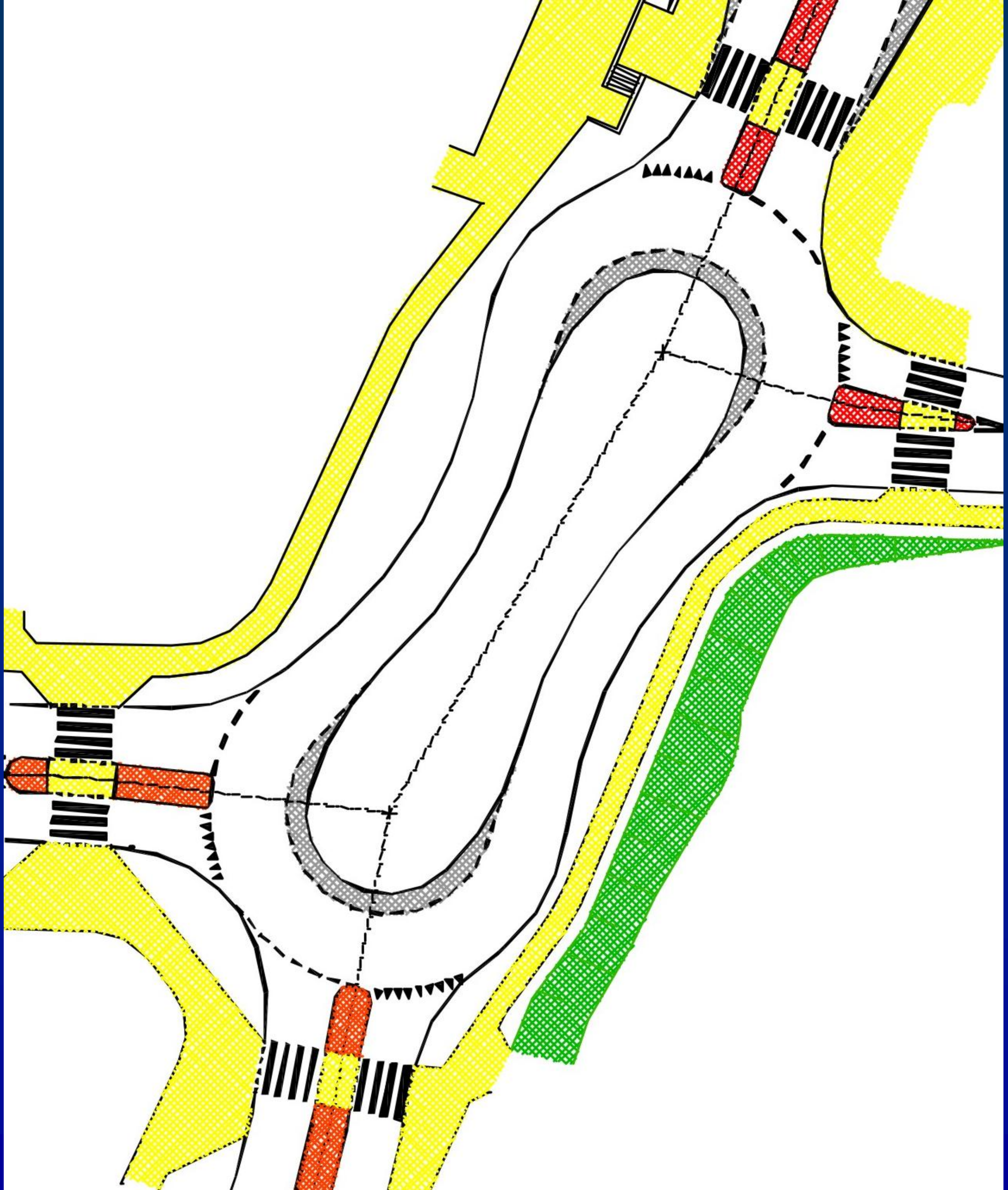
One-lane:

- "∞" and „cigar" shaped roundabouts,
- Double

Double lane:

- turbine roundabouts (Dutch type), spiral
- signalized roundabouts & turbine roundabouts,



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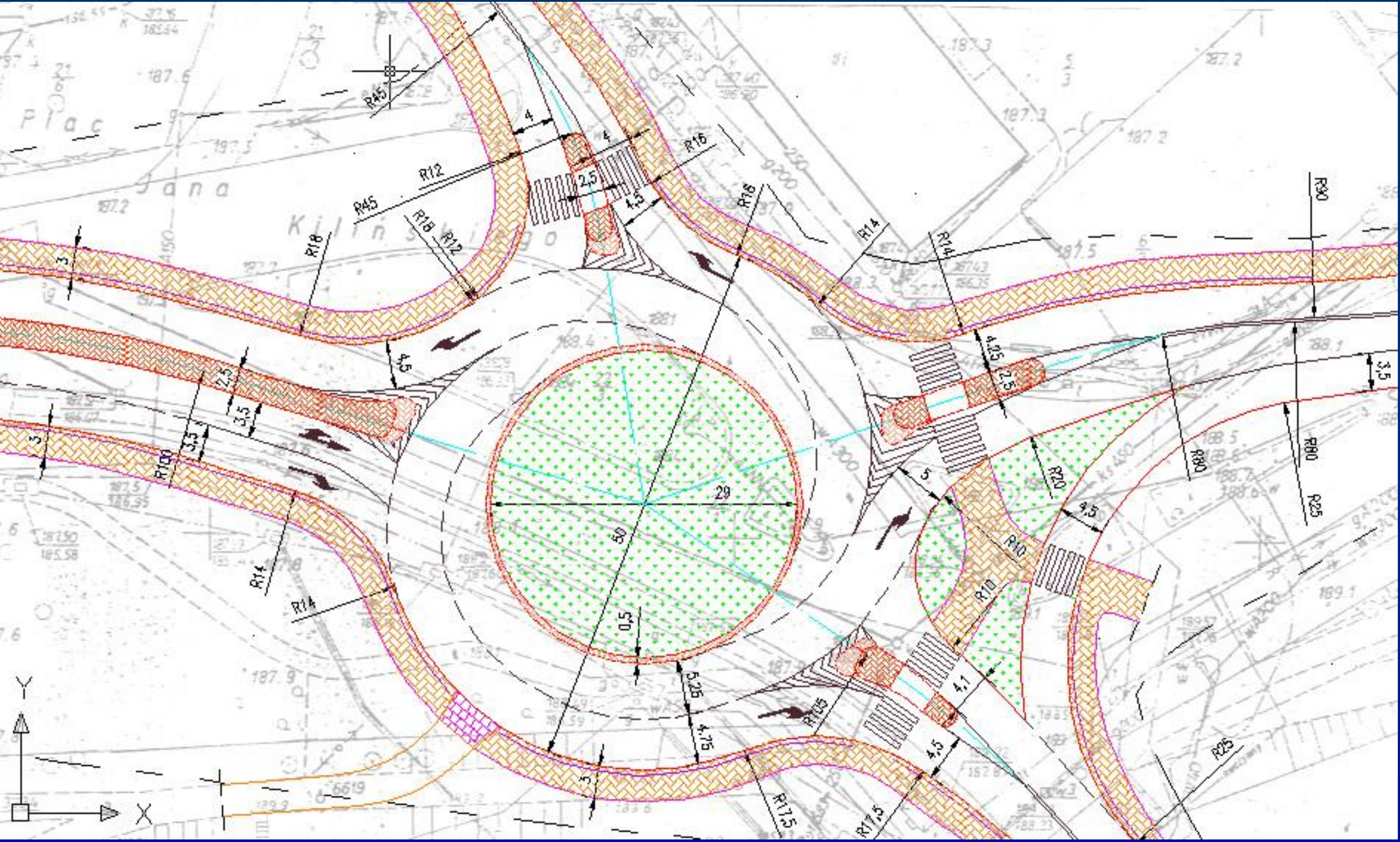
Turbine roundabouts

- A few turbine roundabouts of Dutch type were built on rural roads with or without contra-curves at entries for design traffic volumes < 3000 veh/h
- They are used by small number of cyclists. Pedestrian traffic is almost not present
- Three such roundabouts have been used for more than 2 years and no accidents with victims were recorded. Five more were recently constructed and are under construction

Turbo with contra-curve entries


farby

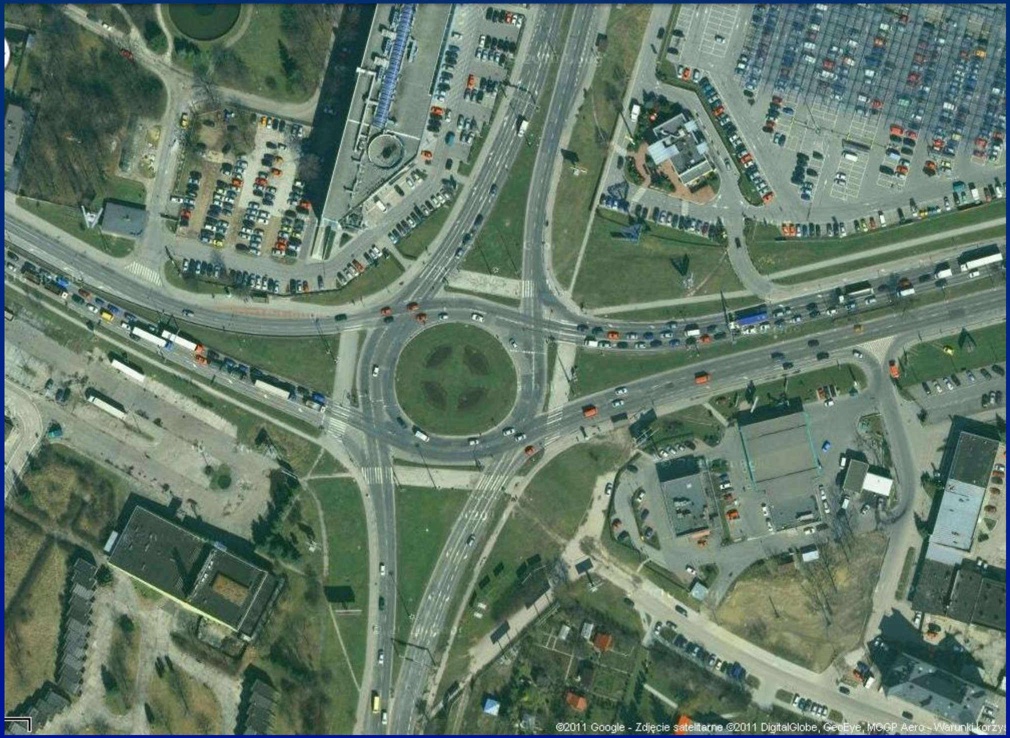
- Some drivers of long trucks do not keep their paths on traffic lane. There are problems with maintenance of separating lines. There are plans to instal better founded separators.
- Some doubts and problems are related to winter maintenance.
- Unexpected lane changes due to bad lane choice were eliminated by building the turbine roundabouts with two lanes at each entry – not required for capacity reasons.
- Capacity studies have not been conducted yet at these roundabouts



Spiral roundabout

3rd International Conference on Roundabouts
May 18-20, 2011 Carmel, Indiana

Roundabouts with Traffic Signals



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- Roundabouts with traffic signals used in Poland in urban areas can provide intersection capacity of about 6500 veh/h in 2x2 lanes arterials or even 8000 veh/h in 2x3 lanes arterials including left-turning movements of 600 veh/h.

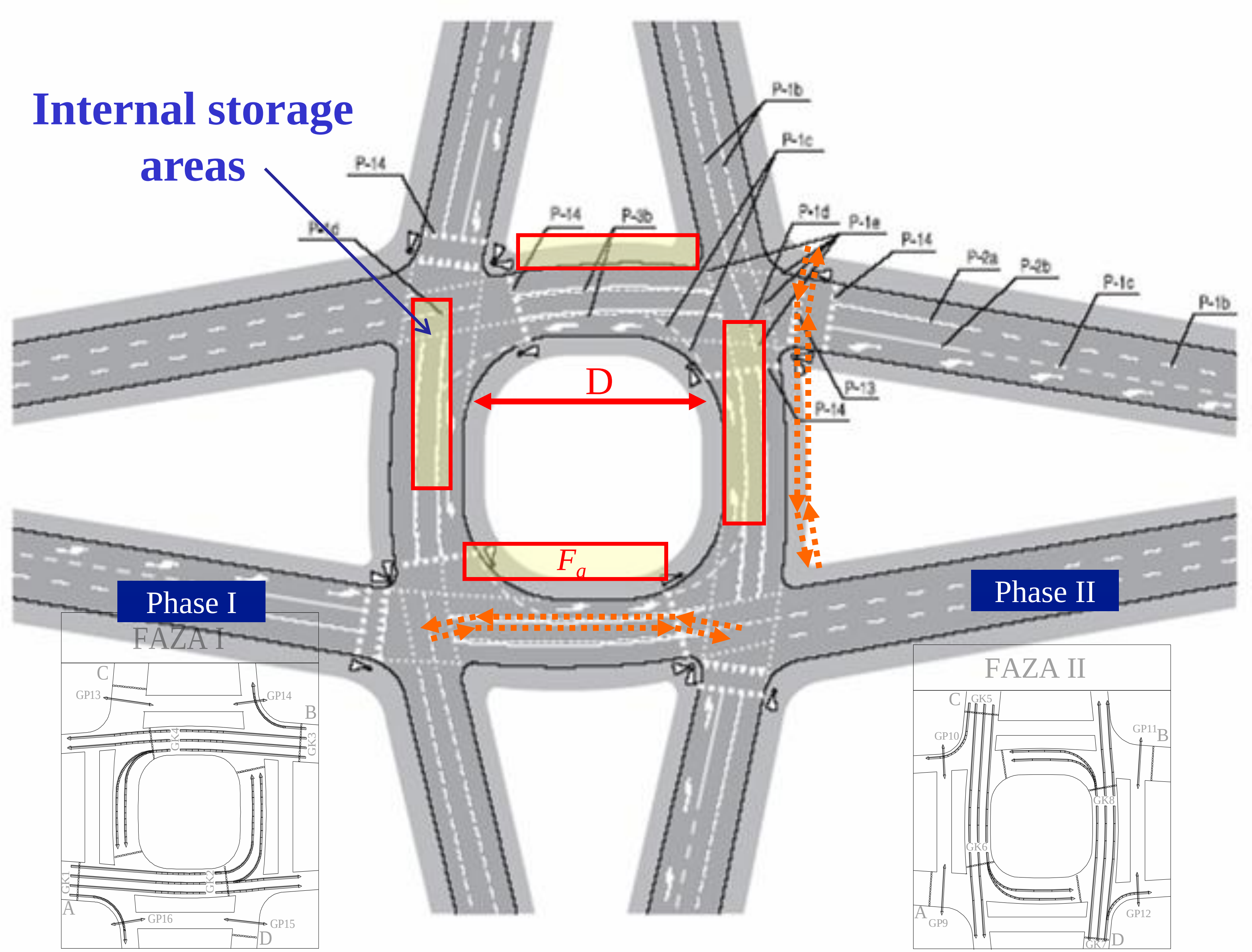
Two characteristic features of their geometry are:

- tangential entry design, i.e. axis of each entry and exit is tangential to axis of circular carriageway around central island,

- importance of four storage areas around the central island for capacity of left turns,

Such roundabouts work well with simple two-phase traffic signals

Roundabouts with Traffic Signals



Roundabouts with Traffic Signals

Capacity and other measures of performance	Case				
	I	II	III	IV	V
	Signalized (2 phases)	Signalized (2+sub phases)	Signalized (3 phases)	Unsignalized (roundabout)	Unsignalized (roundabout with by-passes)
Intersection capacity [veh/h]	8695	6985	5782	3709	4136
Critical rate of flow to capacity V/C [-]	0,58	0,72	0,86	1,34	1,25
Average overall intersection delay [s/veh]	10,4	15,5	29,8	982	436

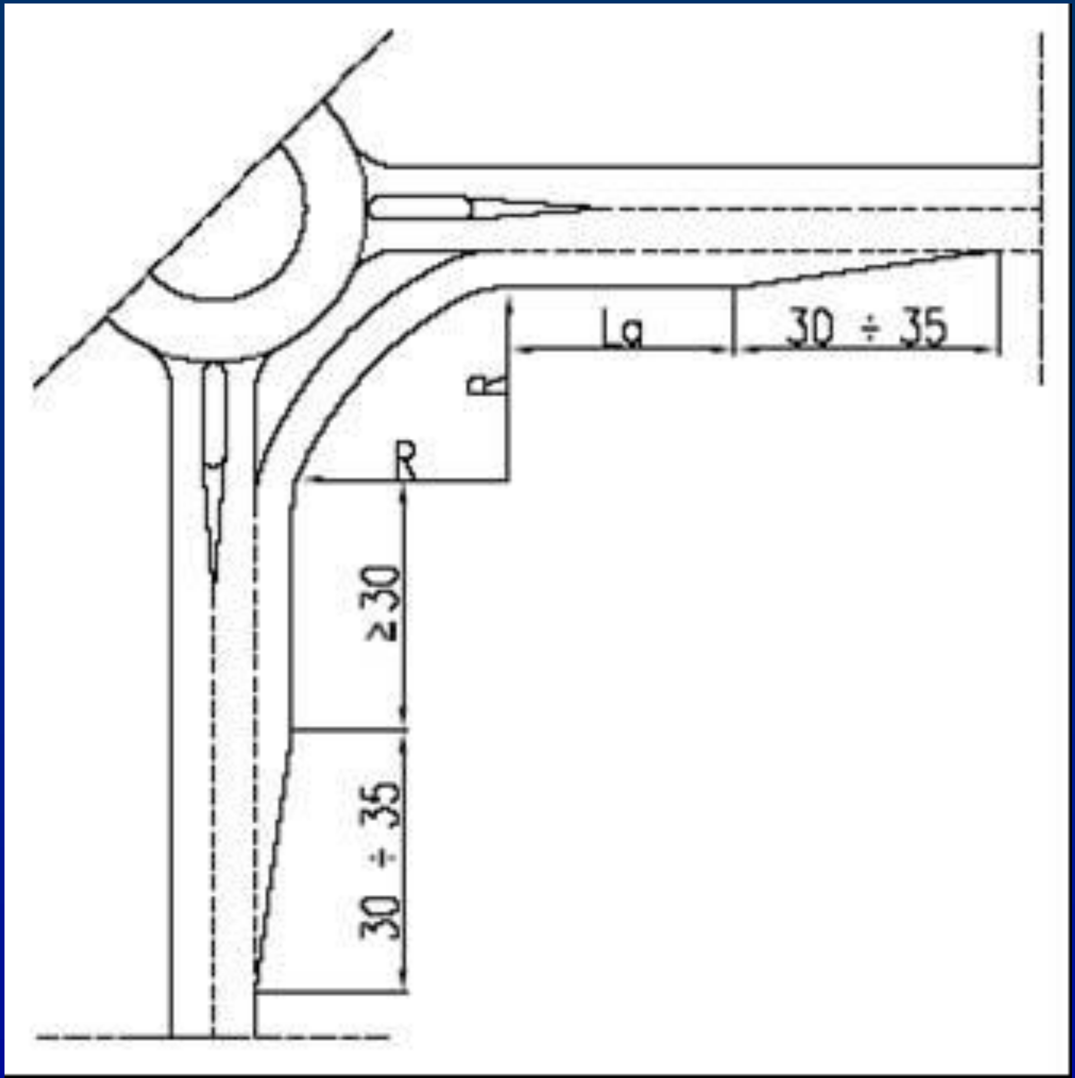
Bypasses of small roundabouts

By-pass is usually used at one (or more) entries with high traffic volumes and noticeable right-turning traffic volume, if simultaneously:

- the predicted traffic volume at considered entry is close to its capacity,
- there is demand for improvement of traffic performance of some roundabout entries.

This issue can be solved by taking away the dominating right turning traffic from the circulatory carriageway,

Typical by-pass design

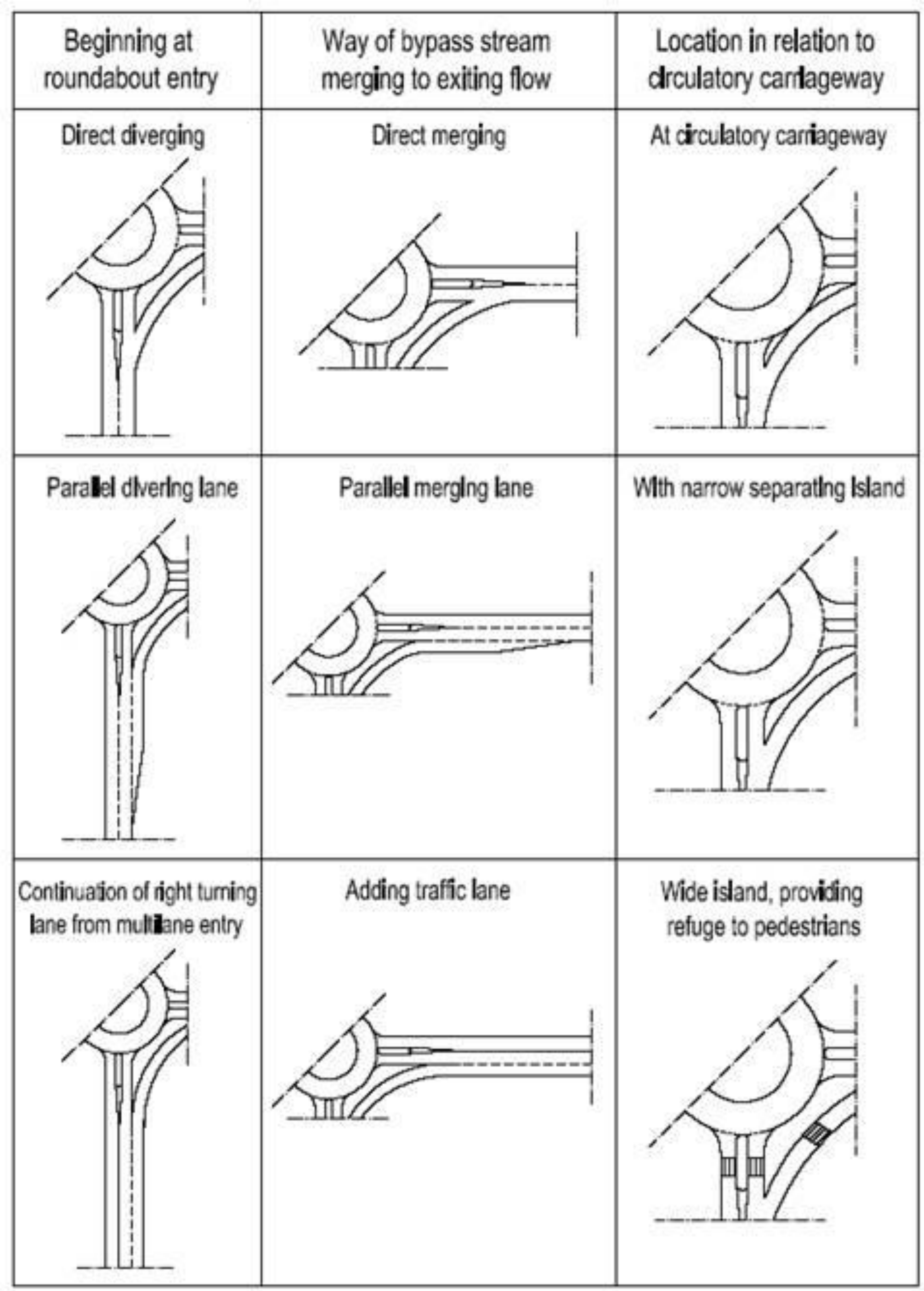


Polish guidelines for designing roundabouts recommend one simple type of right-turn by-pass.

The design should include even short merging lane (>30 m) parallel to the main exit lane for safety of merging and separate right-turning lane at the entry .

Typical design of by-pass

- Geometrical parameters and signing should induce drivers to reduce speed on by-pass
- At short by-passes, the distance travelled in the reaction time (at merging decision) should be taken into account when distance from the circulatory carriageway to the merging point is considered (min.25 m, in PL guidelines min 30m)
- In practice other by-pass designs are also used - depending on terrain limitations and geometrical design of roads entering roundabout.



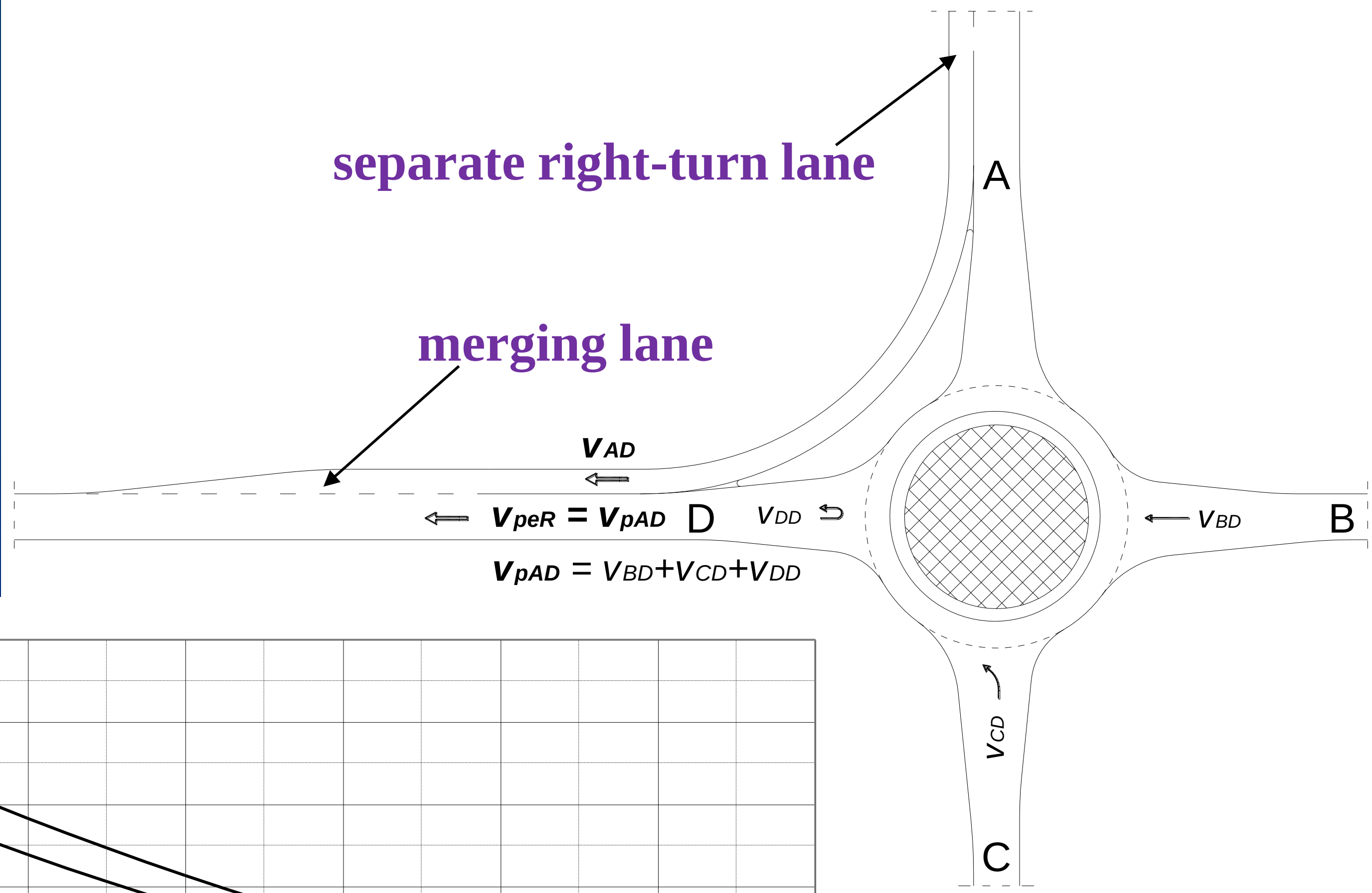
Classification of by-passes with regards to:

a) manner in which by-pass begins at entry;

b) manner in which by-pass lane merges to exit lane

c) its location in relation to circulatory carriageway

Right-turn bypass lane with merging lane
Given in Kansas in 2008



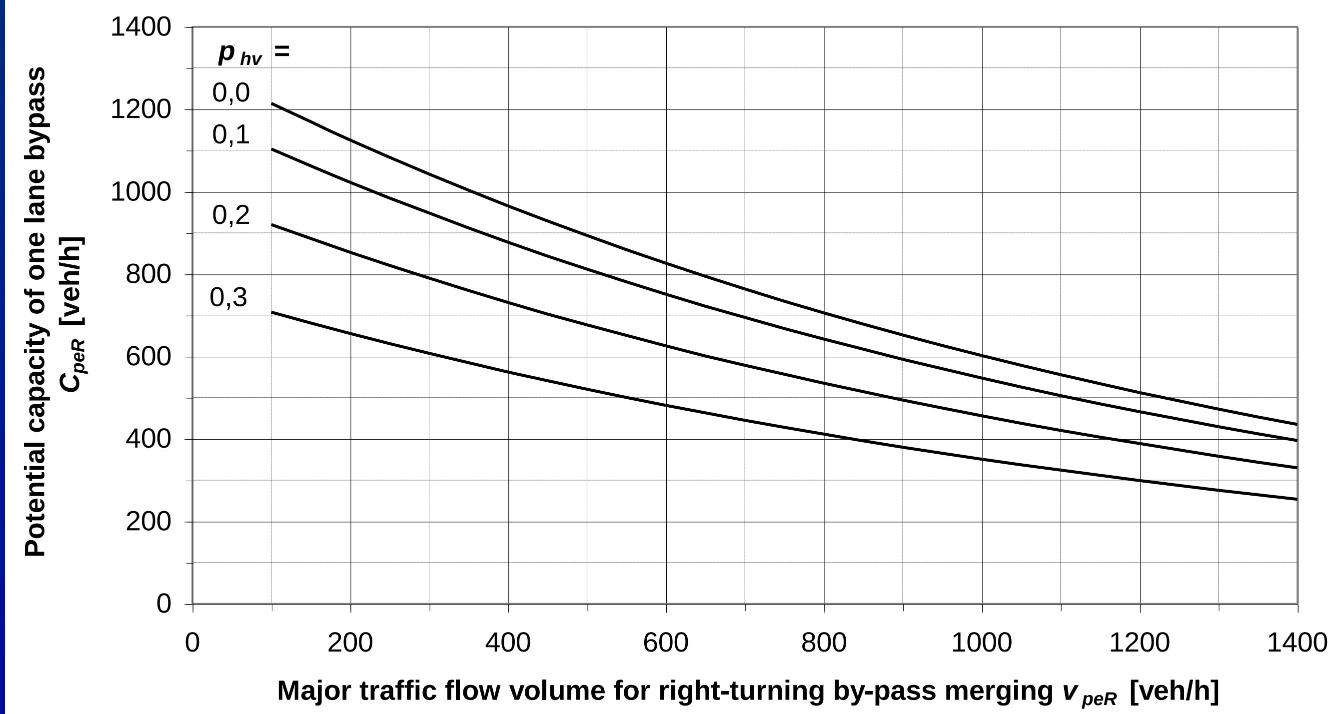


Fig. 8 Potential capacity of one-lane bypass

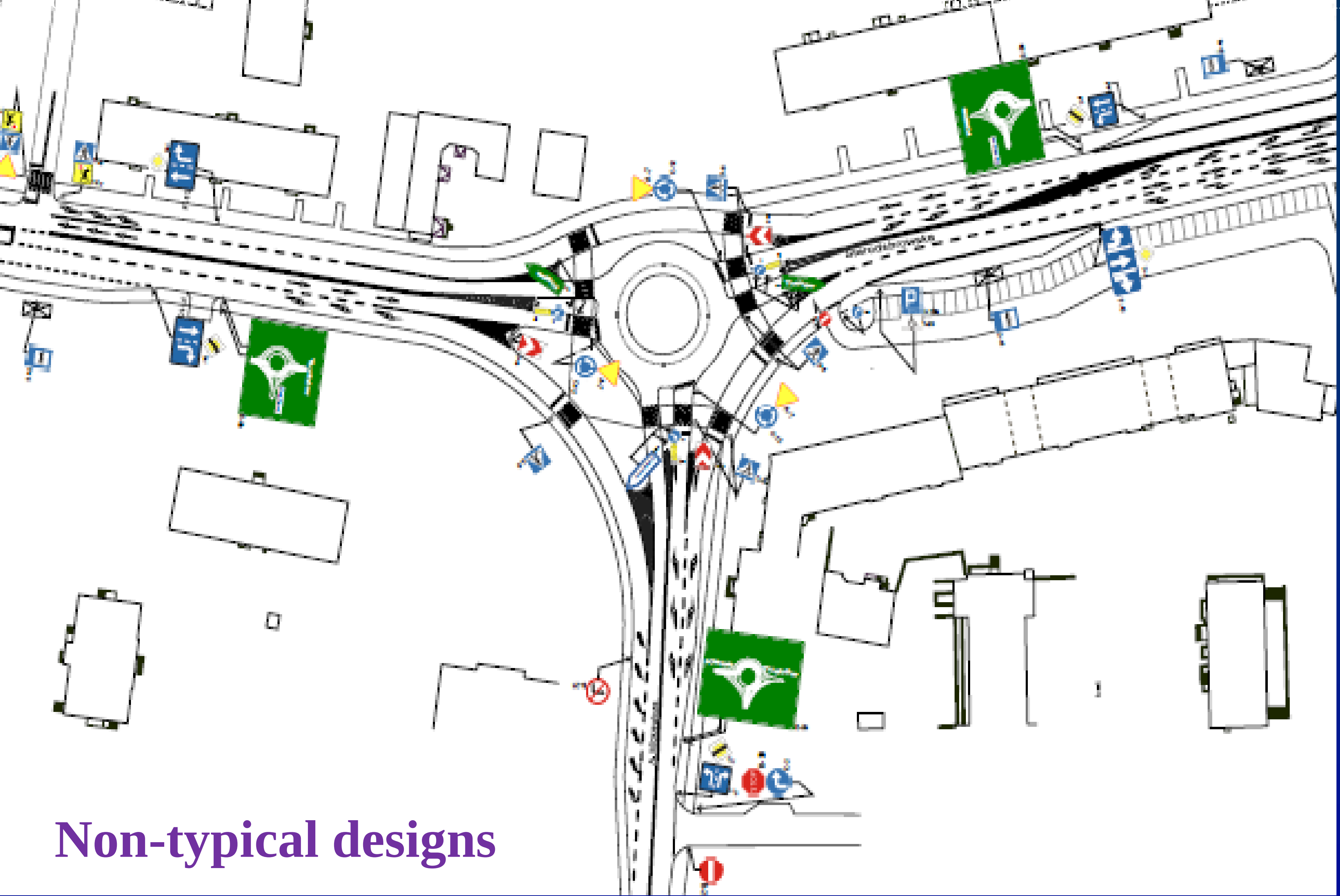
- Capacity values from the diagram do not include an impact of pedestrian traffic using marked pedestrian crossings across the by-pass lane.
- Pedestrians may force vehicles using the by-pass lane to stop, thus reducing its capacity.
- Similarly, pedestrians using the crossing at a roundabout exit can stop the traffic flow leaving the roundabout, making merging of vehicles from the by-pass lane into the main exit lane easier and thus increasing its capacity.
- **These effects need further investigation**

Increase of roundabout capacity when building by-pass depends on volume of by-passed turns

It is usually 200-600 veh/h, at T-intersections even 800-1000 veh/h.

- Encouraging experiences from operation of individual by-passes at existing roundabouts, in some cases have been inspiration for creating its untypical designs, where designers try to link positive features of one-lane roundabouts and by-passes (Figure).
- Straight –through by-pass
- Boomerag separation
- Marked separation

- Pass through the central island for long vehicles



Non-typical designs

Design at large share of straight-through flow volumes at 3-arms.
- significantly increased roundabout capacity.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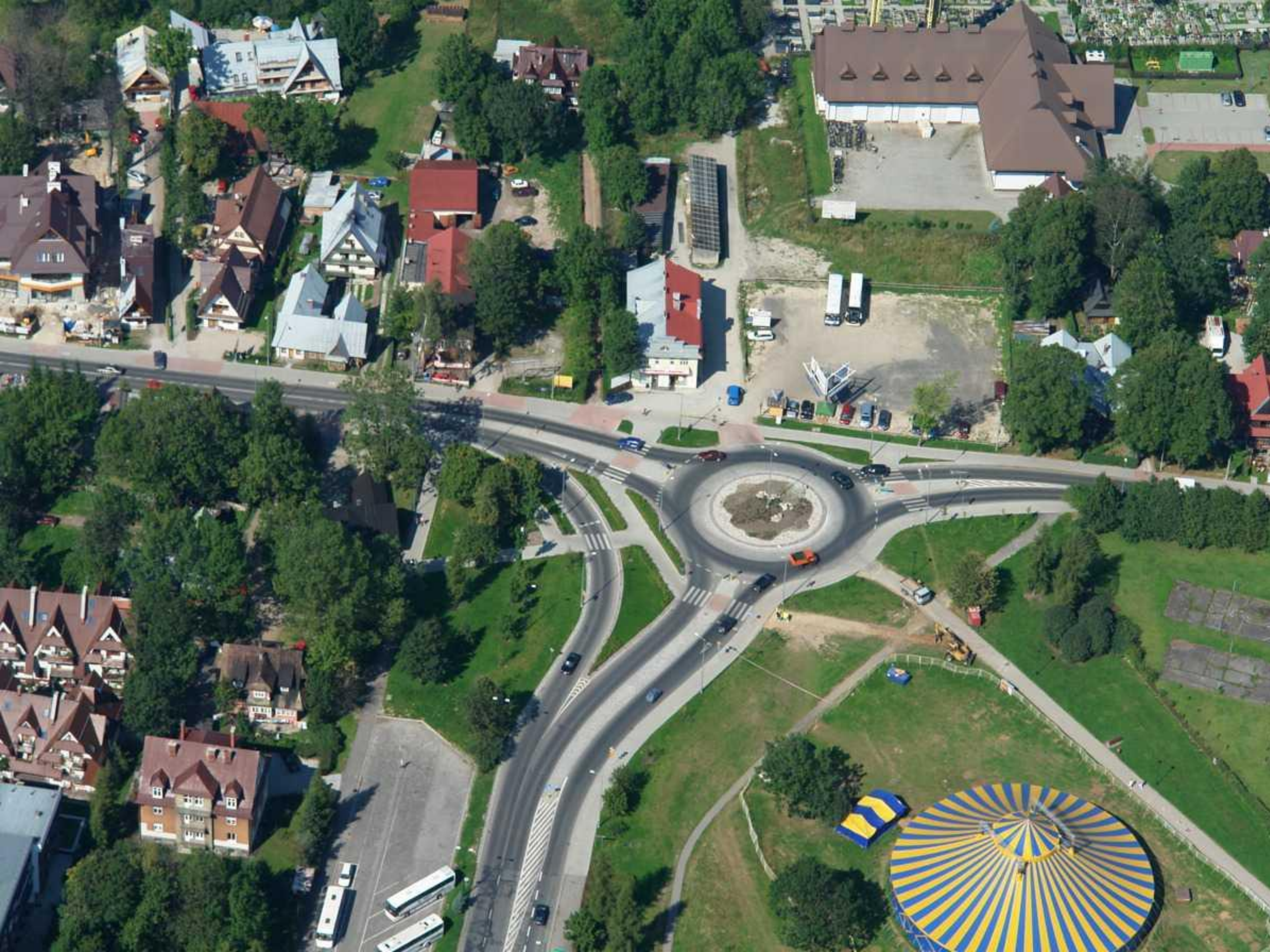


- Line separating right – turn movement

- „Bumerang" island separating right-turn lane

Pass for special very-long wide vehicles (Poznań, PL)

Development of Polish formulae for small roundabout capacity analyses

The model chosen for determining the capacity of minor roundabout entries was Siegloch’s theoretical model calibrated for Polish conditions. It required:

- Empirical measurements of gap acceptance parameters
- Simulation studies
- Impacts of non-stationarity on capacity of roundabout entry

Measurements of gap acceptance parameters

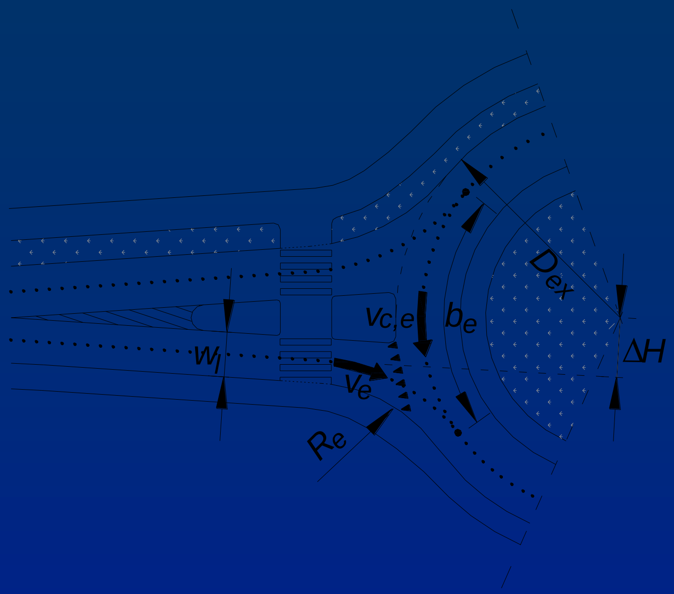


Illustration of roundabout geometric and traffic parameters

Analyses of gap acceptance parameters: critical gap t_c and time headway t_f:

D_{ex} – **inscribed circle diameter** (28 ÷ 44 m),
w_l – **width of entry lane** (3.0 ÷ 5.0 m),
N – **number of entries** (3 or 4),
b_e – **distance between conflict points** (16.2 ÷ 23.0 m), (Fig. 1),
R_e – **entry radius** (8 ÷ 19 m),
ΔH – **offset of the approach lane center line** from the center of the roundabout (3.1 - 11.6 m),
Ni – **size of town/city** (19.6 ÷ 740.0 thousand inhabitants)
$v_{c,e}$ – **circulating flow at entry *e*** (134 ÷ 481 *veh/h*).

Models for the estimation of parameters t_f and t_c for single-lane roundabouts

Towns and cities:

$$t_f = 3.03 - 0.00022 \cdot D_{ex}^{\ 2}$$

time headway

$R^2 = 0.275$, $SE = 0.13$, $MAE = 0.10$

$$t_c = 1.7 \cdot t_f = 5.13 - 0.00038 \cdot D_{ex}^2$$

critical gap

R^2 = – (model without constant), $SE = 0.55$, $MAE = 0.45$

D_{ex} – inscribed circle diameter (28 ÷ 44 m),

Similar relastionships for rural areas

Table 1: Recommended values of parameters t_c and t_f for **two-lane roundabouts** and **semi two–lane roundabouts**

	Critical gap t_c [s]	Follow-up time t_f [s]
Medium two-lane roundabout		
Lane L Lane R	4.3 4.6	3.3 3.6
Large two-lane roundabout		
Lane L Lane R	3.8 4.2	2.6 2.9
Semi two-lane roundabout		
	4.7	2.8

POTENTIAL ENTRY CAPACITY MODELS FOR ROUNDABOUTS

- **Model for single-lane roundabout**:

$$c_{p,e} = \frac{3600}{t_f} \cdot \exp\left[-\frac{v_{c,e}}{3600} \cdot \left(t_c - \frac{t_f}{2} - 0{,}3 \right) \right]$$ [pcu/h] (3)

- **Model for two-lane roundabout** (lane capacity)

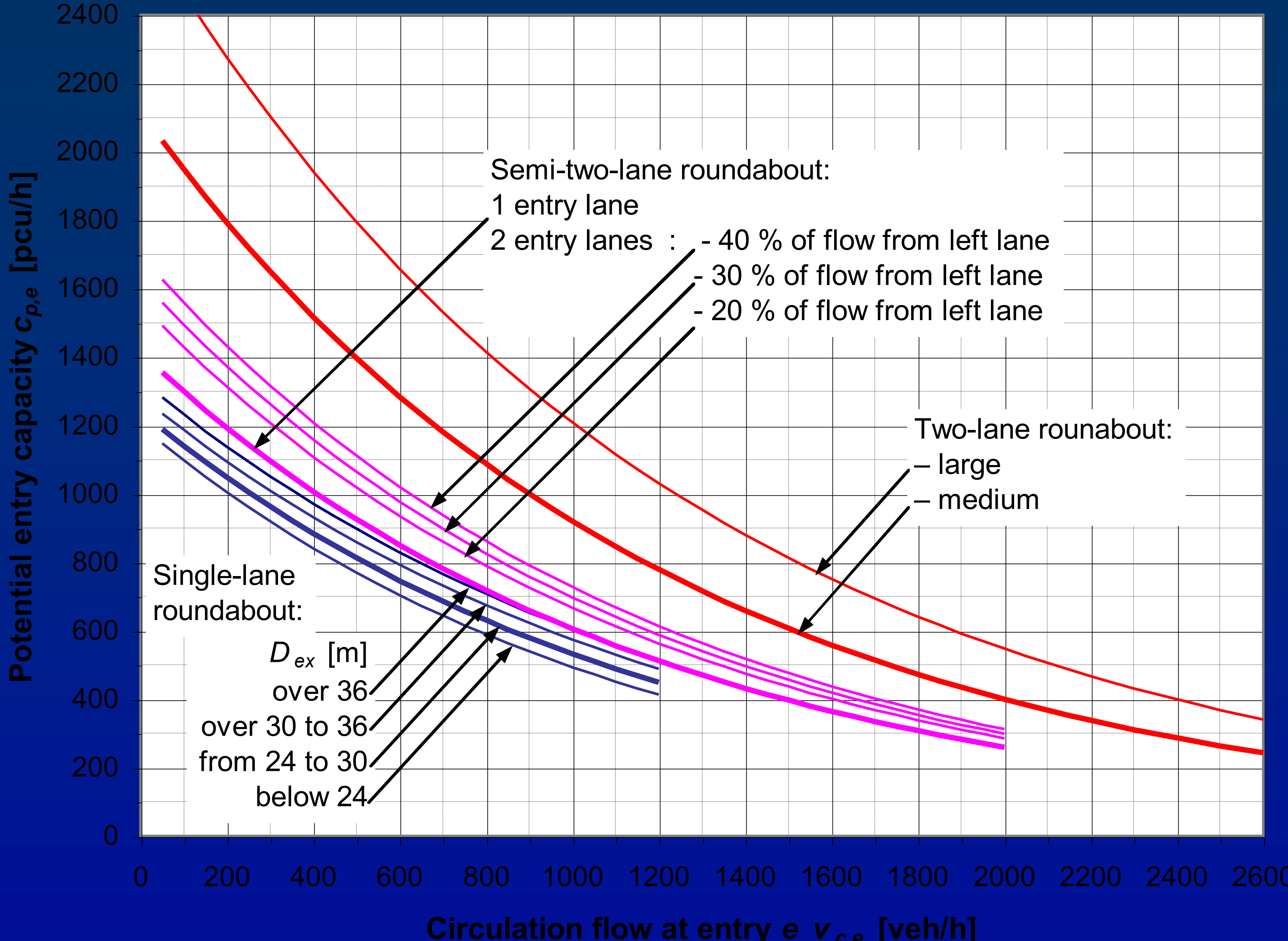
$$c_{p,el} = \frac{3600}{t_f} \cdot \exp\left[-\frac{v_{c,el}}{3600} \cdot \left(t_c - \frac{t_f}{2} + 0.3 \right) \right]$$ [pcu/h] (4)

- **Model for semi-two-lane roundabout** (entry capacity)

$$c_{p,e} = 1.10 \cdot (1 + 0.5 \cdot m_l) \cdot \frac{3600}{t_f} \cdot \exp\left[-\frac{v_{c,e}}{3600} \cdot \left(t_c - \frac{t_f}{2} - 0.25 \right) \right]$$ u/h] (5)

$v_{c,e}$ – circulating flow at entry *e* [veh/h],
t_c, t_f – critical gap [s] and follow-up time [s],
m_l – share of left lane traffic in the total traffic volume at a two-lane entry [-].

ROUNDABOUT CAPACITY ANALYSIS



Comparison of initial capacities on minor entries of a one-lane, two-lane and semi-two-lane roundabout

Conclusions from studies of impacts of non-stationarity of demand flows at roundabout entries on their performance

- Recently the authors conducted studies of impacts of non-stationarity with use of simulation models and computational methods
- In these investigations modelled is traffic variability in various periods of hour or day. Also recorded demand flows were used.

a) It can be assumed that description of demand variability by parabolic or sinusoidal profiles, at the same amplitude gives comparable results of an entry performance

b) Amplitude of demand flow changes has clear impact on traffic performance, whereas sinusoidal profile with one or two extremes is in practice negligible

c) Roundabout is less sensitive to demand flow variability than priority type intersection

Thank you for your attention !