Roundabouts in Germany: State of the Art

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Traditional Roundabout

Münster / Westfalia

Traditional Roundabout

Berlin

Modern Roundabout

Guideline from FGSV

1998

→ 2006

FGSV =
private non-profit organization which develops and edits all standards for road traffic and highway construction

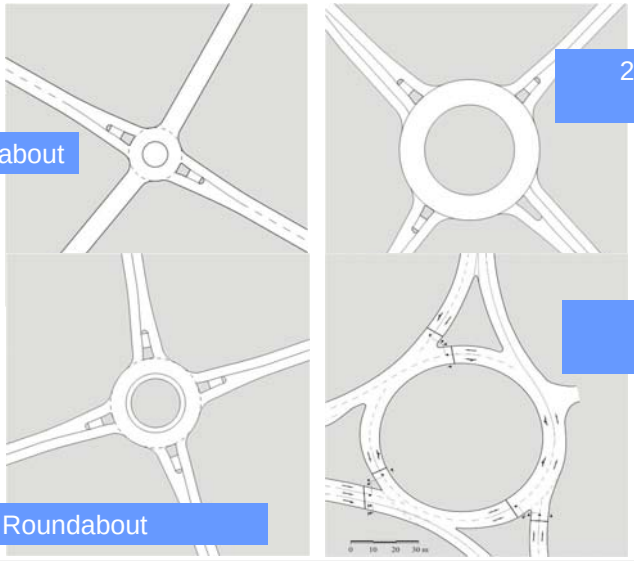
Cologne, Germany

Traffic rules

- **1st mentioning of roundabouts in the German highway code: 1953**
  - priority to the traffic in the circle
- **England: offside priority rule 1966**
  - priority to the traffic in the circle
  - on the circle: priority for vehicles on the inner lanes ←
- **Vienna-convention 1968**
  - unified regulations for traffic rules and signs in Europe
  - no relative priority between vehicles on the circle; ←

    in practice: right before left ,
    i.e. vehicles on the outside have priority
    (contrary to the British rules)

Types of roundabouts - according to FGSV 2006



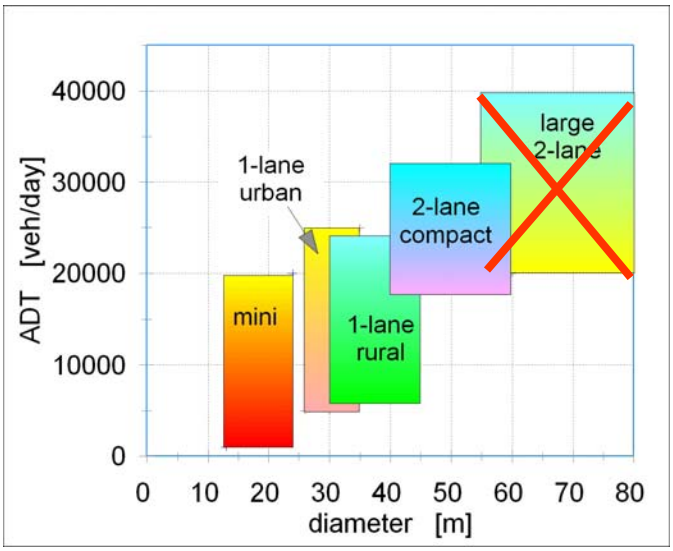
Mini-Roundabout

2-lane compact Roundabout

Signalized Roundabout

Single-lane Roundabout

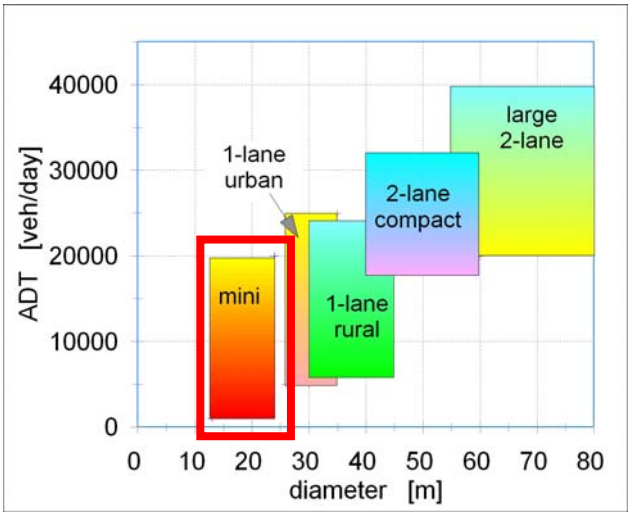
Types of roundabouts - classified by size and daily capacity



Large multilane roundabouts

Europaplatz Aachen

Mini - Roundabouts



Mini - Roundabouts

- Diameter : 13 – 22 m
- traversable island / 4 cm curbs required
- Unexpected large capacity (⇨ ~ 20000 veh/d)
- Very safe
- 4.5 m wide asphalted ring
- Well working, only urban

Mini - Roundabouts

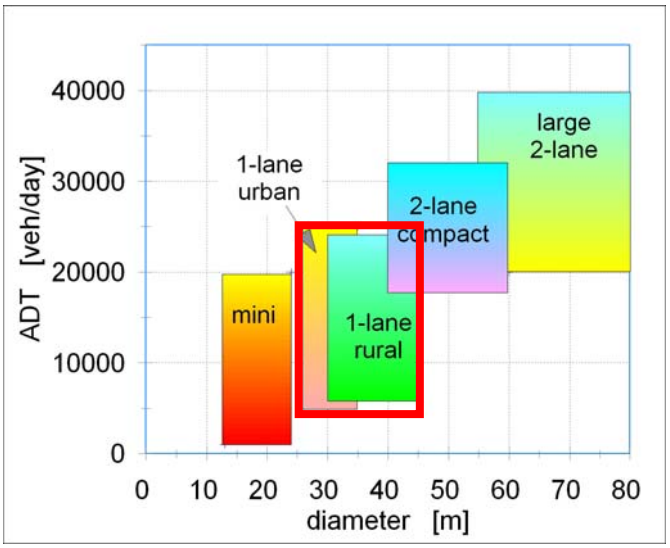
Rural Mini – Roundabouts ?

Rural Mini-Roundabouts:

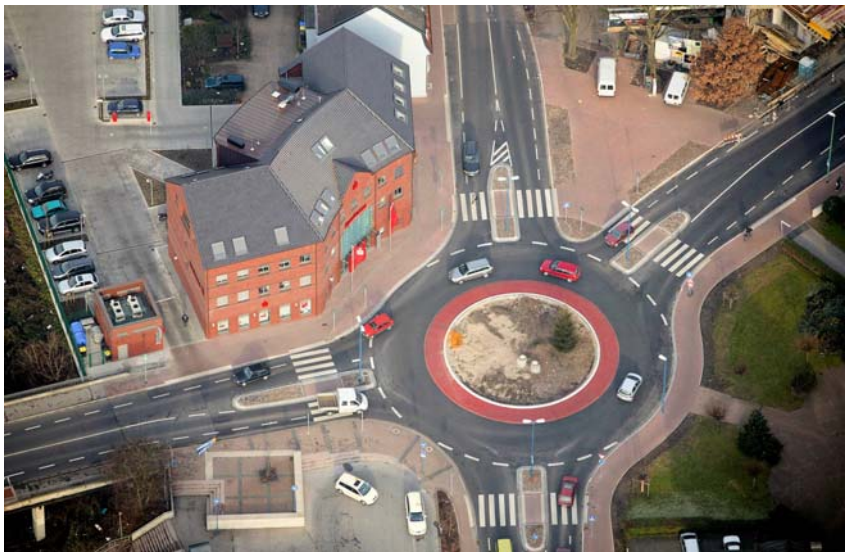
Some experiments (4 locations)

→ not recommended

Standard = single-lane Roundabout



Standard = single-lane Roundabout: typical urban design



Standard = single-lane Roundabout: typical rural design

Single-lane Roundabout

Characteristic design elements

- urban and rural
- Diameter: 26 - 45 m
- circle width: 6 - 8 m
- circle crossfall with 2.5 % to the outside
- central apron
  with min. curb height: 4 cm
- single lane entries + exits
- no flaring of entries
- entries as perpendicular as possible
- entry curb radius 10-14 m (urban) 14-16m (rural)
- exit curb radius 12-16 m (urban) 14-16m (rural)

Single-lane Roundabout: Design

Single-lane Roundabout

- **central apron**
  with min. curb height: 4 cm ~ 1 inch
  (only urban and with small diameter)

Single-lane Roundabout

Main characteristics :

- safest type of all intersections
- capacity up to 25 000 veh. /day

Single-lane Roundabout: Pedestrians

Pedestrians :

- Pedestrians enjoy short or no delays and a high level of safety
- Zebra-Crossing as the standard solution

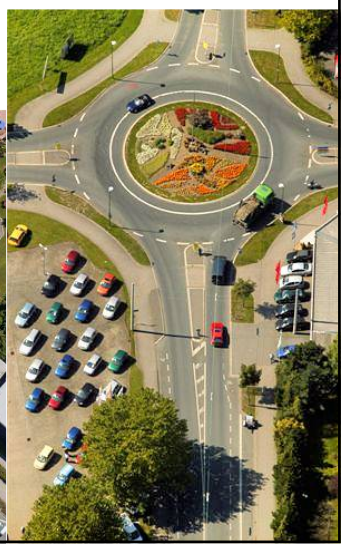
Single-lane Roundabout: Pedestrians

- Zebra-Crossings

Single-lane Roundabout: Pedestrians

Pedestrians :

- Also without Zebra-Crossing pedestrians have no problems



Single-lane Roundabout: Bicycles

Bicycles :

- Can be guided through the roundabout together with cars up to 15 000 veh/day (urban)

Single-lane Roundabout: Bicycles

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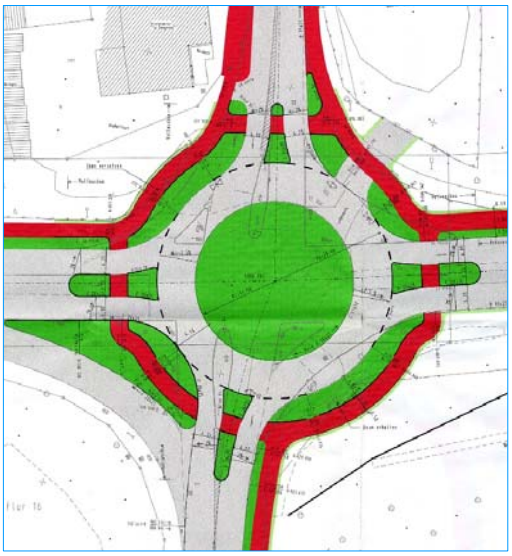
Bicycles at any type of roundabout

Never guide cyclists on a cycle track through the roundabout
very dangerous !

Single-lane Roundabout: Bicycles

Bicycles :
A useful solution is also established by separated cycle tracks

- Separation of crossings from the circle by 5 m
- Urban: priority for cyclists



separated cycle tracks → „ghostdriver“ cyclists

Single-lane Roundabout: Bicycles

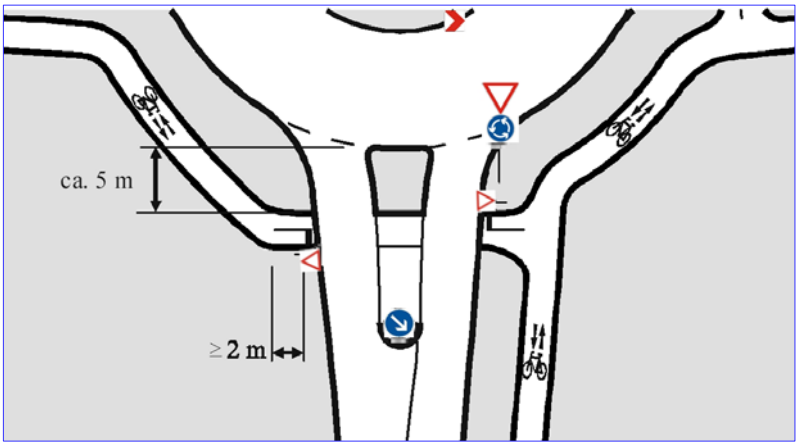
Bicycles :

- Separate cycle tracks: Separation of crossing from the circle by 5 m

Single-lane Roundabout: Bicycles

Bicycles :

- Separate cycle tracks: Separation of crossing from the circle by 5 m
- **Rural**: no priority for cyclists



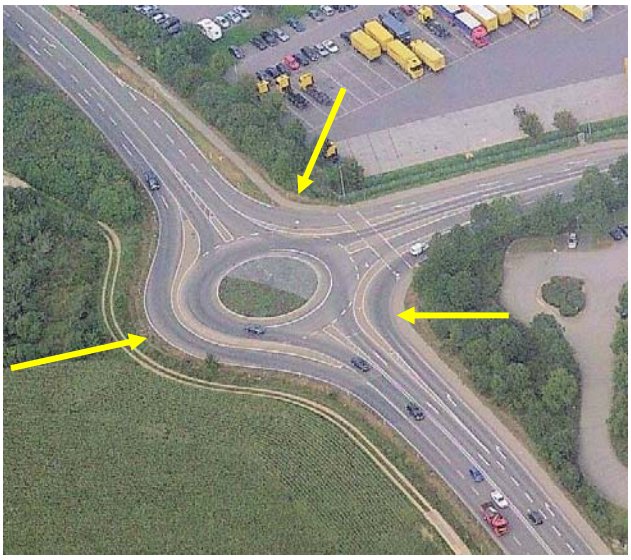
Single-lane Roundabout: Bicycles

Bicycles :

- Separate cycle tracks: Separation of crossing from the circle by 5 m

- **Urban**: with priority for cyclists
- **Rural**: no priority for cyclists

Bypass lanes



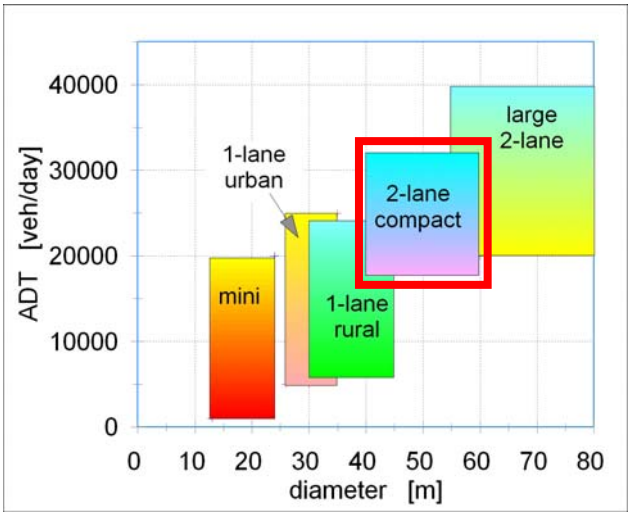
Bypass =
direct right turning lanes

Bypass lanes

- A bypass is a good solution to increase capacity
- Separation from the circle by curbs and islands (not just road markings)

- Acceleration lane (no acute angled entries)

Compact semi-2-lane Roundabout



Compact semi-2-lane Roundabout

Compact semi-2-lane Roundabout

Compact semi-2-lane Roundabout

To be applied :

- No or few pedestrians and cyclists
- Therefore: mainly rural or peripheral urban

Design rules:

- Circular roadway 8 – 10 m wide
- No lane markings in the circle
- Diameter 40 – 60 m
- No cyclists admitted to the circle
- Only 1-lane exits
- 2-lane entries, only where required
- No priorities for pedestrians or cyclists (no Zebra!)

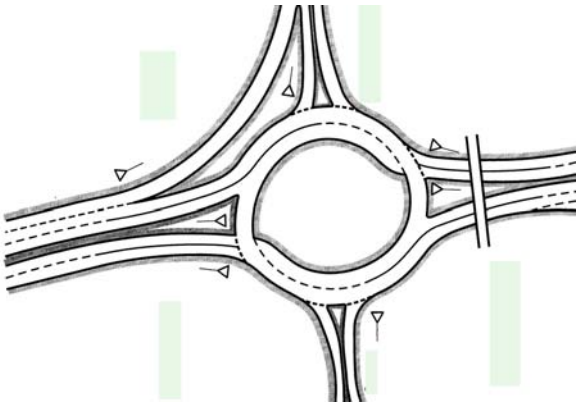
No problems
with path-overlap

Turbo-Roundabout

What is a Turbo-Roundabout ?

Roundabout with

- a variable number of lanes
- without lane changes on the circle



What is a Turbo-Roundabout ?

Entries

Type	Sketch	Characterisation
IN1		„Turbo-Entry“ (2 → 1)

Exits

Type	Sketch	Characterisation
EX1		„Turbo-Exit“ With lane separation

What is a Turbo-Roundabout ?

Typical:

no driver must or should change lanes within the circle
(except for turning, which is not encouraged)

Netherlands

Turbo-roundabout Netherlands

Netherlands → Germany

NL: Characteristicts:

- narrow curvature
- curbs in the middle of the roadway
  on the circle and in the approaches

Problems with application in Germany:

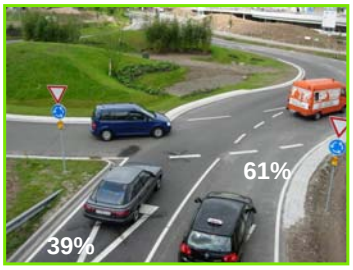
- curbs impede snow removal for winter maintenance
- risk for motor cyclists

- → no curbs on the roadway in Germany

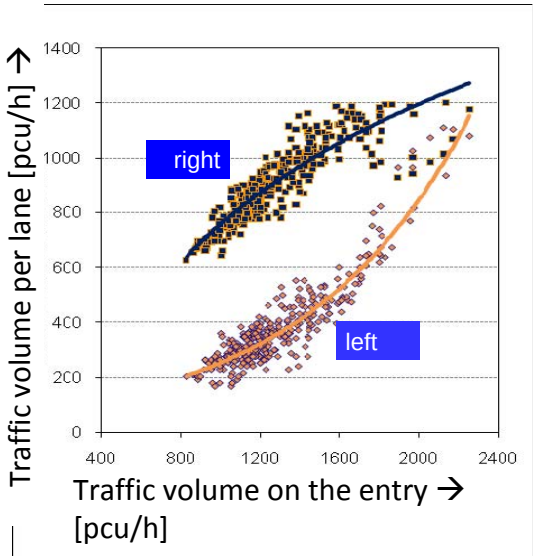
Turbo-Roundabout in Baden-Baden (since 2006)

Utilisation of Entry Lanes

	left lane	right lane
Entry	24 – 40 %	60 - 76 %
Exit	23 – 40 %	60 - 77 %



Utilisation of Entry Lanes

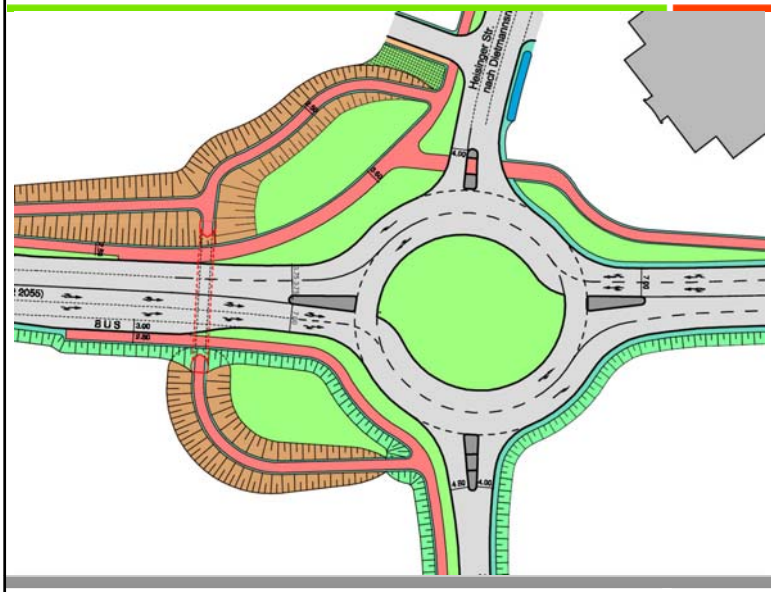


Observation of Lane Marking

More Turbo-Roundabouts in Germany

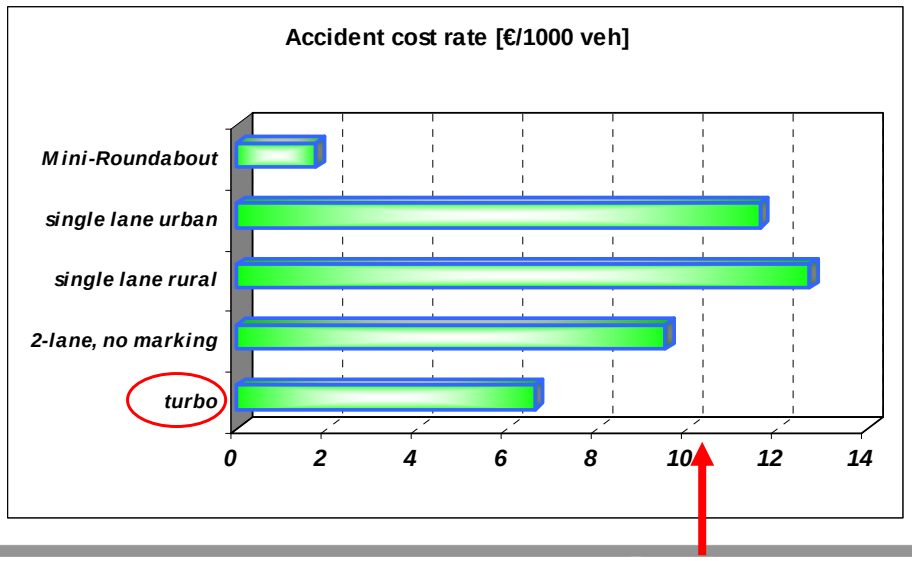
Offenburg

More Turbo-Roundabouts in Germany



Typical design

Accident cost rates (UKR in €/1000 veh)



Capacity of the entries to a Roundabout

$$G = 3600 \cdot \left(1 - \frac{t_{min} \cdot q_k}{n_k \cdot 3600}\right)^{n_k} \cdot \frac{n_z}{t_f} \cdot e^{-\frac{q_k}{3600} \cdot \left(t_g - \frac{t_f}{2} - t_{min}\right)}$$

critical gap theory

HBS 2001

G	=	**entry capacity**	[pcu/h]
q_c	=	traffic volume on the circle	[pcu/h]
n_k	=	no. of lanes in the circle	[-]
n_z	=	no. of lanes in the entry	[-]
t_c	=	critical gap	[s]
t_f	=	follow-up time	[s]
t_{min}	=	minimum gap in the circle	[s]

$$G = A - B \cdot q_c$$

$$G = C \cdot e^{-D \cdot q_c}$$

useful

Empirical Regression method

Capacity: Mini & 1-lane

$$G = 3600 \cdot \left(1 - \frac{t_{min} \cdot q_k}{n_k \cdot 3600}\right)^{n_k} \cdot \frac{n_z}{t_f} \cdot e^{-\frac{q_k}{3600} \cdot \left(t_g - \frac{t_f}{2} - t_{min}\right)}$$

Critical Gap Theory
(with parameters estimated by regression)

G = capacity of an entry [pcu/h]

	n_e	n_k	t_c	t_f	t_{min}
Mini $13 \le d \le 26$ m	1	1	$t_c = 4.9 - \frac{0.4}{13} \cdot d$	$t_f = 3.1 - \frac{0.1}{13} \cdot d$	$t_{min} = 3.9 - \frac{0.9}{13} \cdot d$
compact 1-lane $26 \le d \le 40$ m	1	1	$t_c = \frac{1}{14} \cdot (52{,}2 + 0{,}2 \cdot d)$	$t_f = \frac{1}{14} \cdot (51 - 0{,}4 \cdot d)$	$t_{min} = 6 - 0{,}15 \cdot d$

t_c = critical headway [s]
t_f = follow-up time [s]
t_{min} = minimum headway on the circle [s]
d = diameter [m]

Brilon and Wu 2008

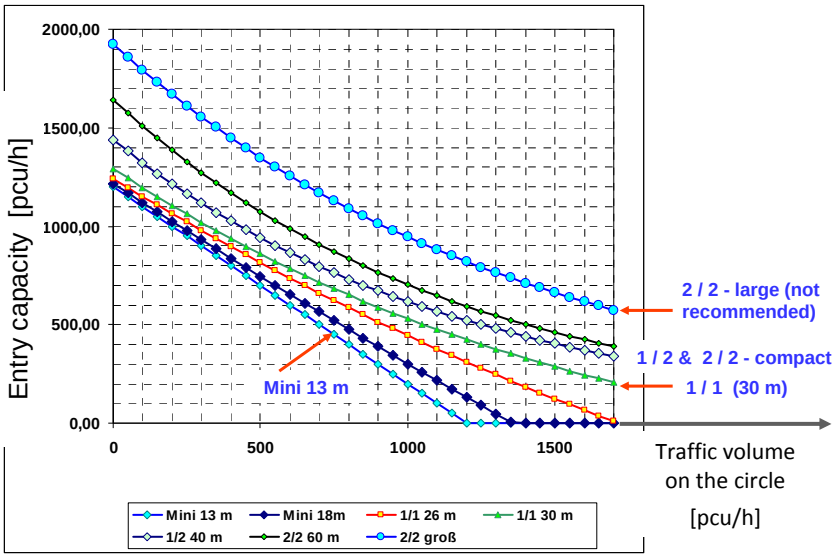
Capacity: 2-lane

$$G = C \cdot e^{-D \cdot q_c}$$

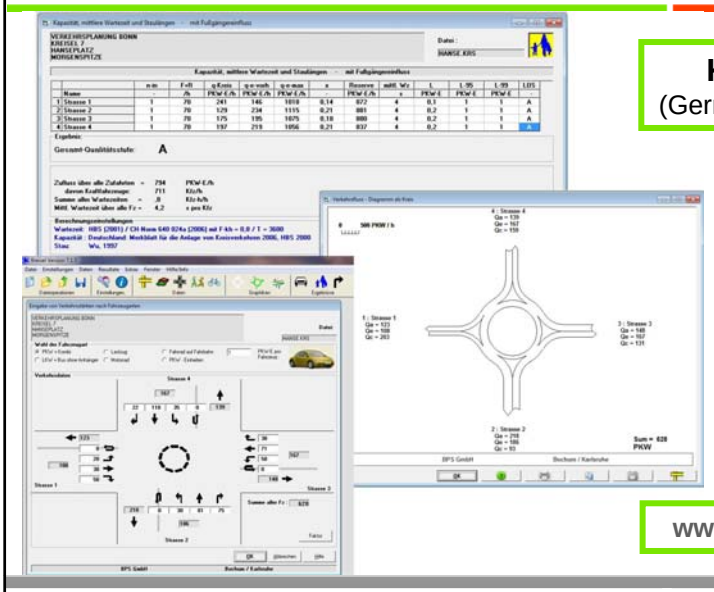
Empirical regression Theory

	n_e	n_k	
compact 2-lane $40 \le d \le 60$ m	1	2	$q_{e,max} = 1440 \cdot e^{-\frac{q_k}{1180}}$
compact 2-lane $40 \le d \le 60$ m	2	2	$q_{e,max} = 1642 \cdot e^{-\frac{q_k}{1180}}$
large 2-lane d >> 60 m	2	2	$q_{e,max} = 1926 \cdot e^{-\frac{q_k}{1405}}$

Capacity:



Capacity: Software



KREISEL 7.1
(German English Italian)

Models from
- **USA**
- **Germany**
- **UK**
- **France**
- **Swiss**
- **Austria**
- **…**

www.bps-verkehr.de

Capacity:

No. of lanes Entry / circle :	1/1	compact 2/2	large 2/2	With signals 2/2
No calculations required →	15 000	16 000	20 000	
Maximum capacity →	25 000	32 000	35 000 - 40 000	50 000 - 60 000
	veh/day			

General remarks

- Roundabout is always circular (not oval)
- No dangerous obstacles on the central island (like trees, monuments, walls, high kerbs)
- Visibility during darkness may be a problem
- Urban: always illuminated
- Rural: reflecting chevrons

General remarks

- Landscaping and architectural design is important for public acceptance

Leinfelden near Stuttgart

General remarks

- Landscaping and architectural design
  is important for public acceptance

Bad Herrenalb near Karlsruhe

Curiosities:

Gasoline station in the center
of a roundabout

Singen near Konstanz

General aspects:

- Roundabouts cause less energy consumption and emissions
- Roundabout reduces noise emission by 3 – 5 %
  (compared to a signal)
- Roundabout is cheaper than a traffic signal
- Roundabouts are highly appreciated
  by citizens and politicians

Conclusions

- **single-lane roundabouts are among the safest types of all kinds of intersections**
- **design should be speed-reducing**
- **capacity is unexpectedly large - but limited**
- **single-lane roundabouts are a very favorable type of intersection under all possible aspects**

- **larger roundabouts are treated with care in Germany**
- **compact-2-lane can be recommended**
- **larger than the compact 2-lanes are not favored due to safety reasons**
- **2-lane exits are banned**
- **cyclists are banned on multilane roundabouts**

- **Turbo-Roundabouts combine high safety standards with larger capacities**

- **larger signalized roundabouts can be a useful solution under rather specific circumstances**

the end

Thank you for your attention