Roundabout - Design and Capacity
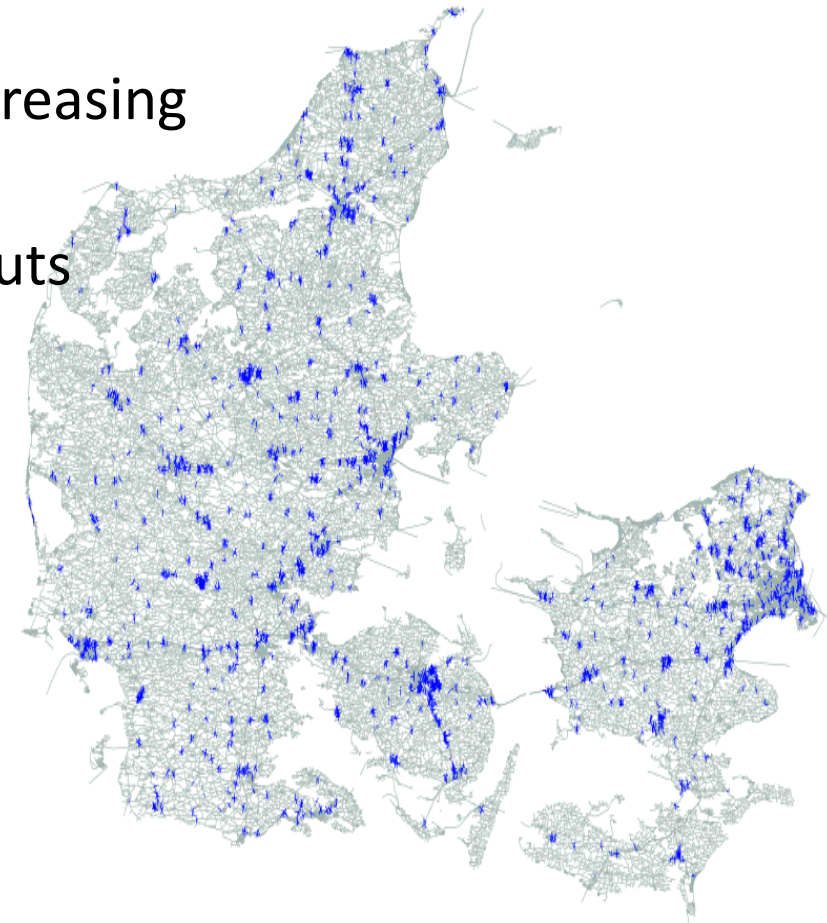

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Introduction

- 1 lane roundabouts – used for decades
  - mainly due to safety problems

- Number of 2 lane roundabouts increasing
  - mainly due to capacity problems
- Today - more than 1400 roundabouts

Distribution of roundabouts

Type	Urban	Rural	Total
Mini	10%	0%	10%
1 –lane	55%	30%	85%
2 –lane	0%	5%	5%
Total	65%	35%	100%

Introduction

- 1 lane roundabouts – used for decades
  - mainly due to safety problems

- Number of 2 lane roundabouts increasing
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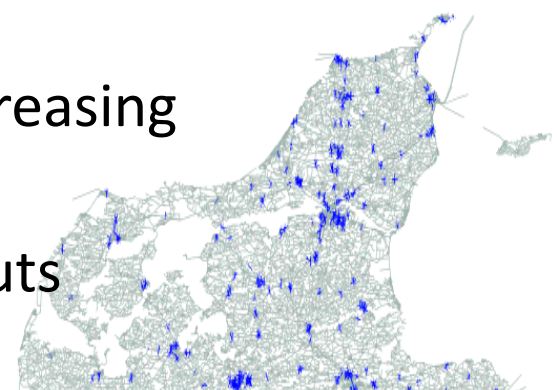- Today - more than 1400 roundabouts

1970's

Early 1980's

2009

Design – Urban

- Mini / 1 lane
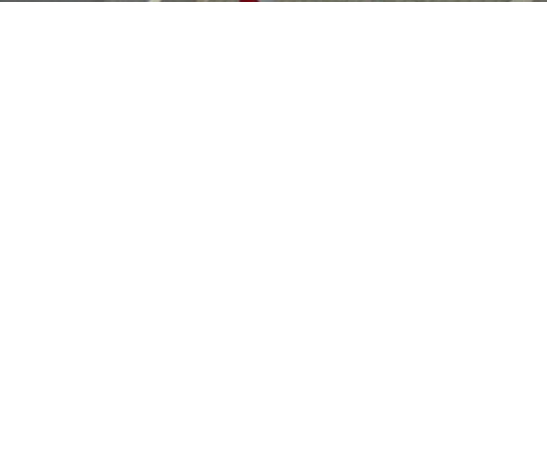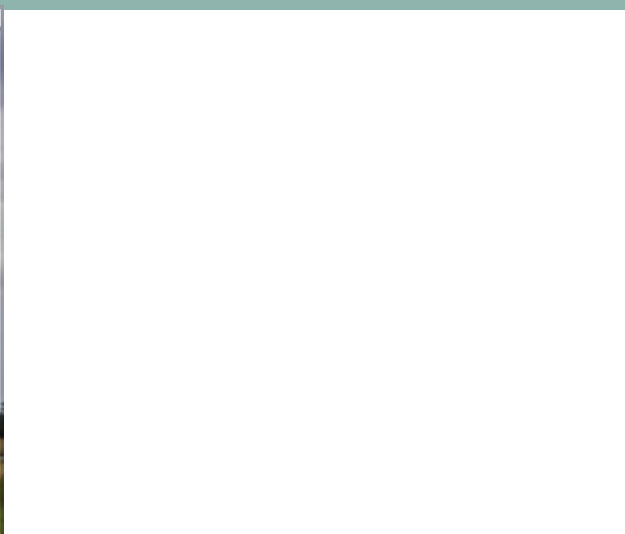- Facilities for pedestrian and cyclists

Design – Rural

- 1- and 2-lane
- Central island – 30-60 m
- No facilities for pedestrians
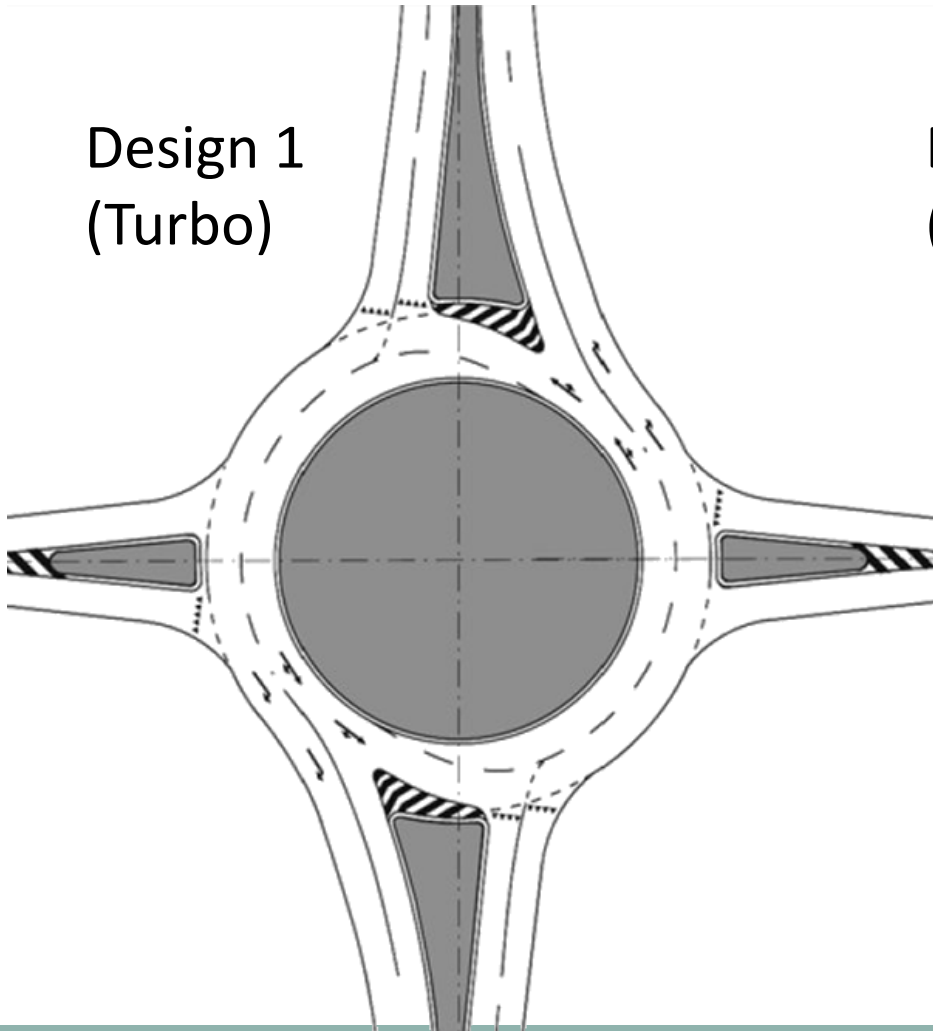- 2-lane – no facilities for cyclist inside the roundabout crossings will be recessed

Marking of 2-lane roundabouts

Design 1
(Turbo)

Design 2
(Traditional)
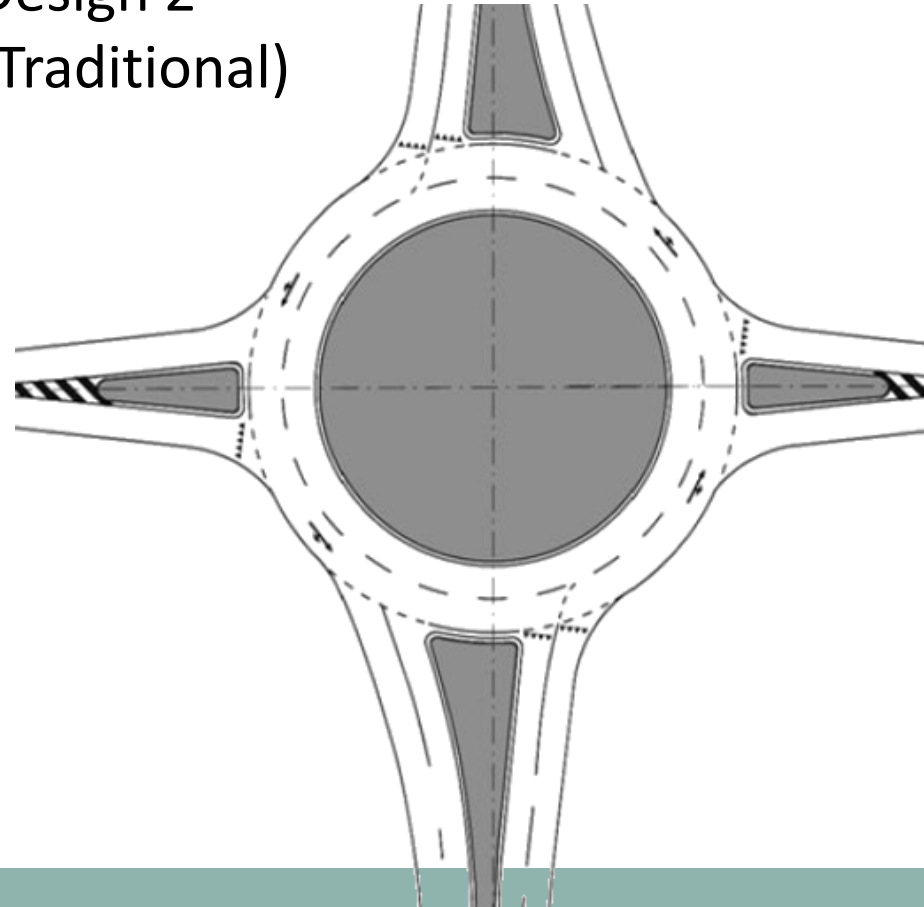
Danish Design Guidelines
Web: www.vejregler.dk

Capacity of entry lane

$$G = \frac{q_c \cdot e^{-\left(\frac{q_c \cdot t_g}{3600}\right)}}{1 - e^{-\left(\frac{q_c \cdot t_f}{3600}\right)}}$$

where

G   =   basic capacity of entry lane (pcu/h)

q_c =   circulating traffic flow (pcu/h)

t_g =   critical gap (sec)

t_f =   follow up time (sec)

Studies on capacity and driver behaviour

- Capacity of one-lane roundabouts (2004)
- Capacity of two-lane roundabouts (2007)
- Lane use and conflicts at two lane roundabouts (2008)

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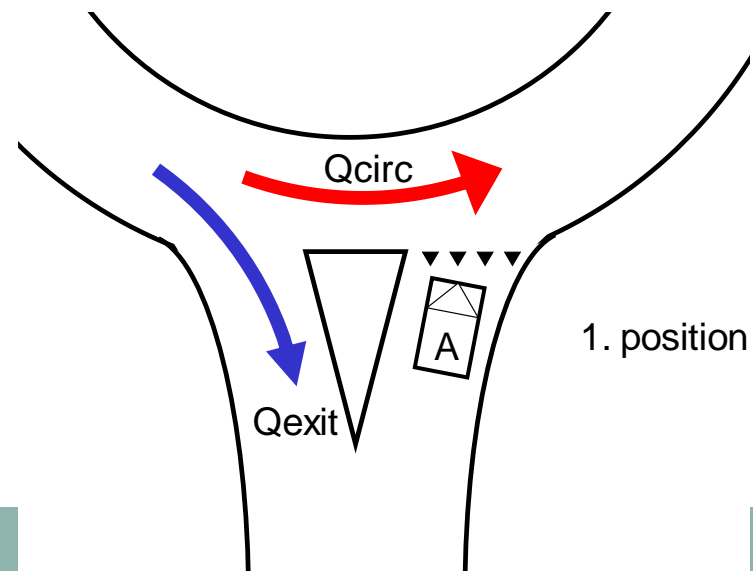**Driver behaviour at 1-lane roundabouts (only passenger cars)**

• Critical gap (tg)   [4.1 -5.7 sec]
• Follow up time (tf) [2.5 – 3.6 sec]

• Critical gap / follow up time vs. design parameters

Type	Critical gap (tg)	Follow up (tf)
Urban	5.1 sec	3.0 sec
Rural	4.7 sec	3.0 sec

One lane - roundabouts

Average waiting time in 1. queue position (sec)

Number of vehicles leaving (Qexit)	Number of circulating vehicles (Qcirc)				
	0	1	2	3	4
0	1.5 sec	4.0 sec	6.3 sec	8.5 sec	9.1 sec
1	1.9 sec	4.6 sec	7.0 sec	9.1 sec	11.9 sec
2	2.3 sec	5.5 sec	7.1 sec	10.6 sec	14.5 sec
3	3.6 sec	7.1 sec	9.6 sec	11.4 sec	11.3 sec

Driver behaviour at 2-lane roundabouts

-Data from five 2-lane roundabouts
-Total of seven entries

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Estimated critical gap

Marking Design	Entry Lane	
	Left	Right
Design 1 (turbo)	3.9 sec	3.9 sec
Design 2 (traditional)	4.1 sec	4.2 sec

Follow up times (passenger cars)

	Entry lane	
	Left	Right
Design 1 (turbo)	2.6 sec	2.7 sec
Design 2 (traditional)	2.5 sec	2.6 sec
Average	2.6 sec	2.7 sec

Two lane - roundabouts

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Follow up times (passenger cars)

	Entry lane	
	Left	Right
Design 1 (turbo)	2.6 sec	2.7 sec
Design 2 (traditional)	2.5 sec	2.6 sec
Average	2.6 sec	2.7 sec

Average follow up time by car position

	Position in queue			
	2	3	4	5
Average follow up time	3.1 sec	2.5 sec	2.4 sec	2.2 sec

PCU –values

Truck/bus
(8 – 13 m)

Semitrailer/truck w. trailer
(13 – 22 m)

Follow up time and critical gap

Entering vehicle	Follow up time
Passenger car	2.7
Truck/bus	4.3
Semitrailer/truck w. trailer	6.1

Follow up time and critical gap

Entering vehicle	Follow up time	Critical gap for entering vehicle against:	
		Passenger car	Truck/bus/semi trailer/truck w. trailer
Passenger car	2.7	4.0	4.4
Truck/bus	4.3	4.9	5.3
Semitrailer/truck w. trailer	6.1	5.9	5.3

PCU values for heavy vehicles

Vehicle type	PCU-values	
	Entering flow	Circulating flow
Truck/bus	1.7	1.5
Semitrailer/truck w. trailer	2.5 (2.3-3.0)	1.9

Empirical data

Circulating flow

Exiting flow

Entering flow

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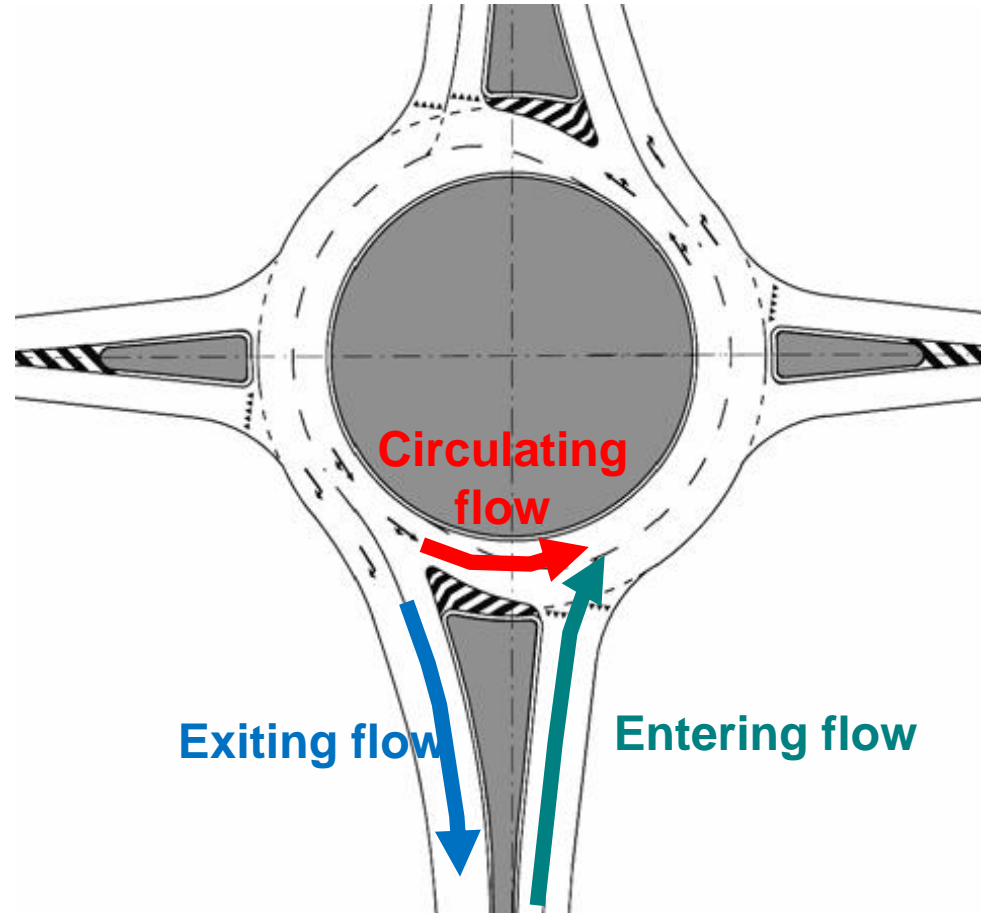
Empirical data – example:

Design 1 (Turbo) – right entry lane

Legend:
- No 1 - north
- No 1 - south
- No 2 - east
- No2 - west
- No 3 - north
- No 4 - north
- tg=4.0 sec, tf=2.6 sec
- Best fit - all data

$y = 404{,}12e^{-0{,}004x}$
$R^2 = 0{,}7207$

X-axis: **Circulating flow (pcu pr 15min)**
Y-axis: **Entering flow (pcu/15min)**
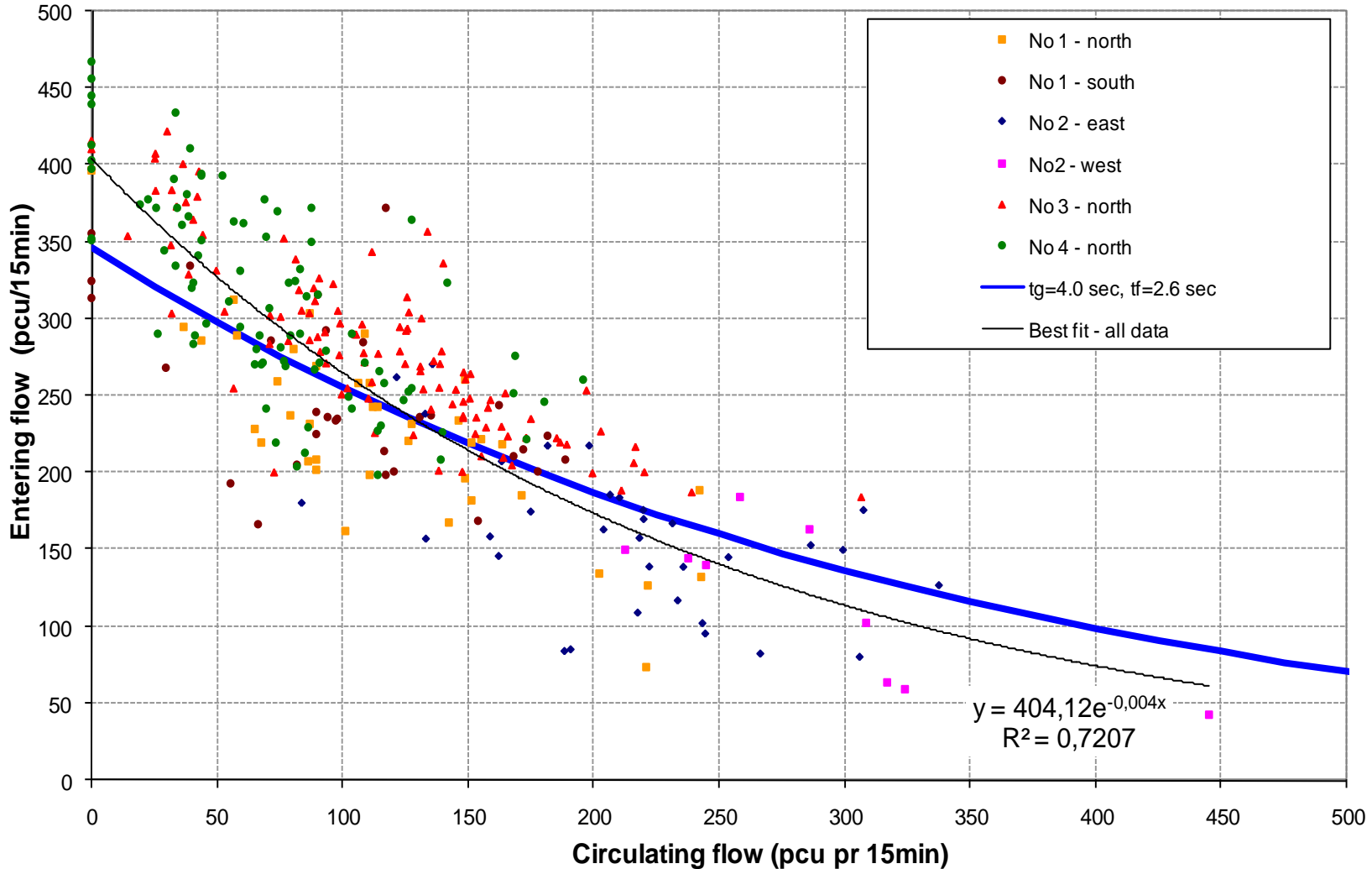
Alternative approach:

Basic gap
acceptance model:

$$G = \frac{q_c \cdot e^{-\left(\frac{q_c \cdot t_g}{3600}\right)}}{1 - e^{-\left(\frac{q_c \cdot t_f}{3600}\right)}}$$

where

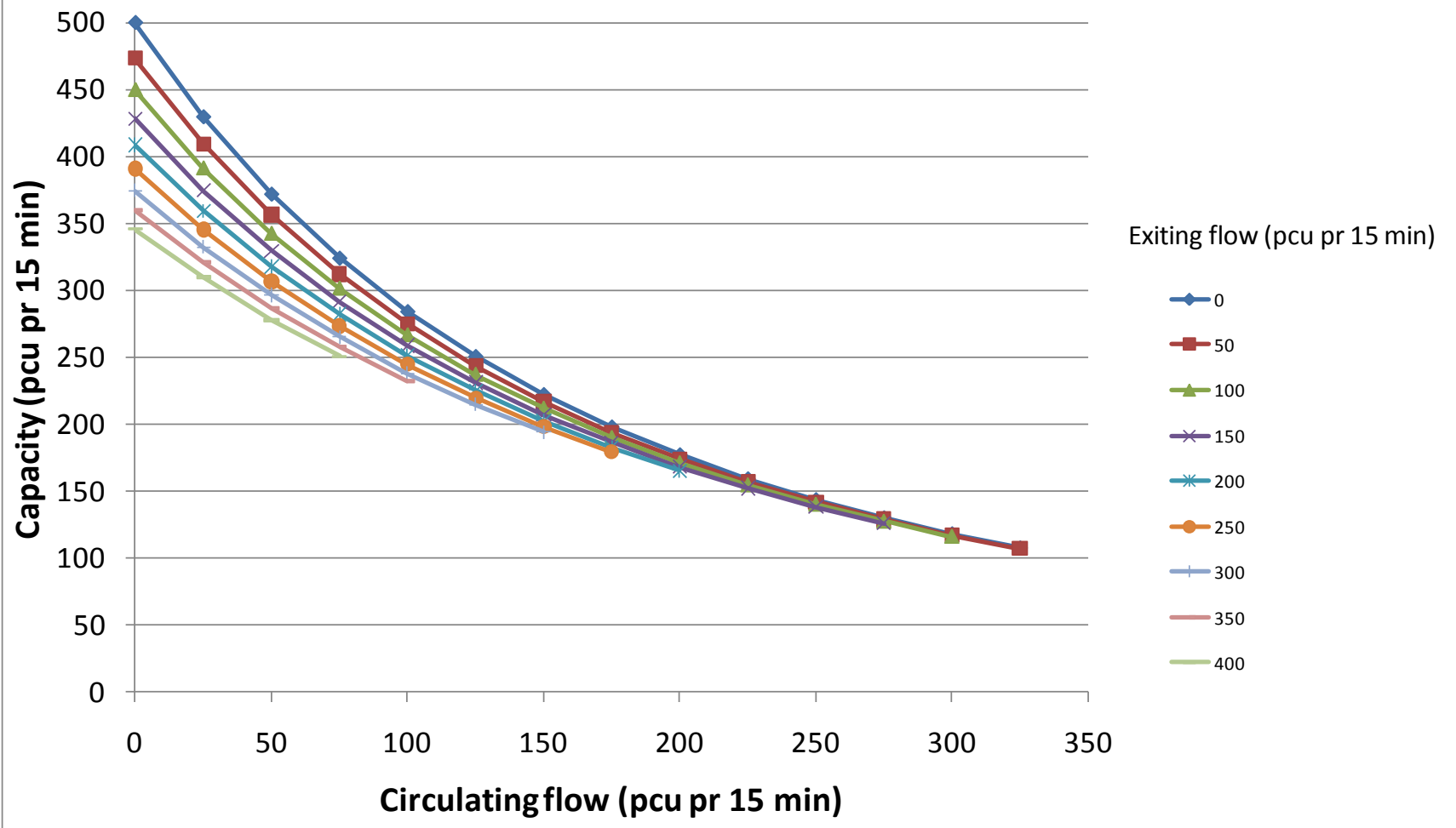|		
G	=	basic capacity of entry lane (pcu/h)
q_c	=	circulating traffic flow (pcu/h)
t_g	=	critical gap (sec)
t_f	=	follow up time (sec)

Estimated follow
up time:

$$t_f = 1.8 + (0.004 \cdot q_e) \cdot (1 - 0.0013 \cdot q_c) + 0.005 \cdot q_c$$

where

t_f	=	follow up time (sec)
q_c	=	circulating flow (pcu pr 15 min)
q_e	=	exiting flow (pcu pr 15 min)

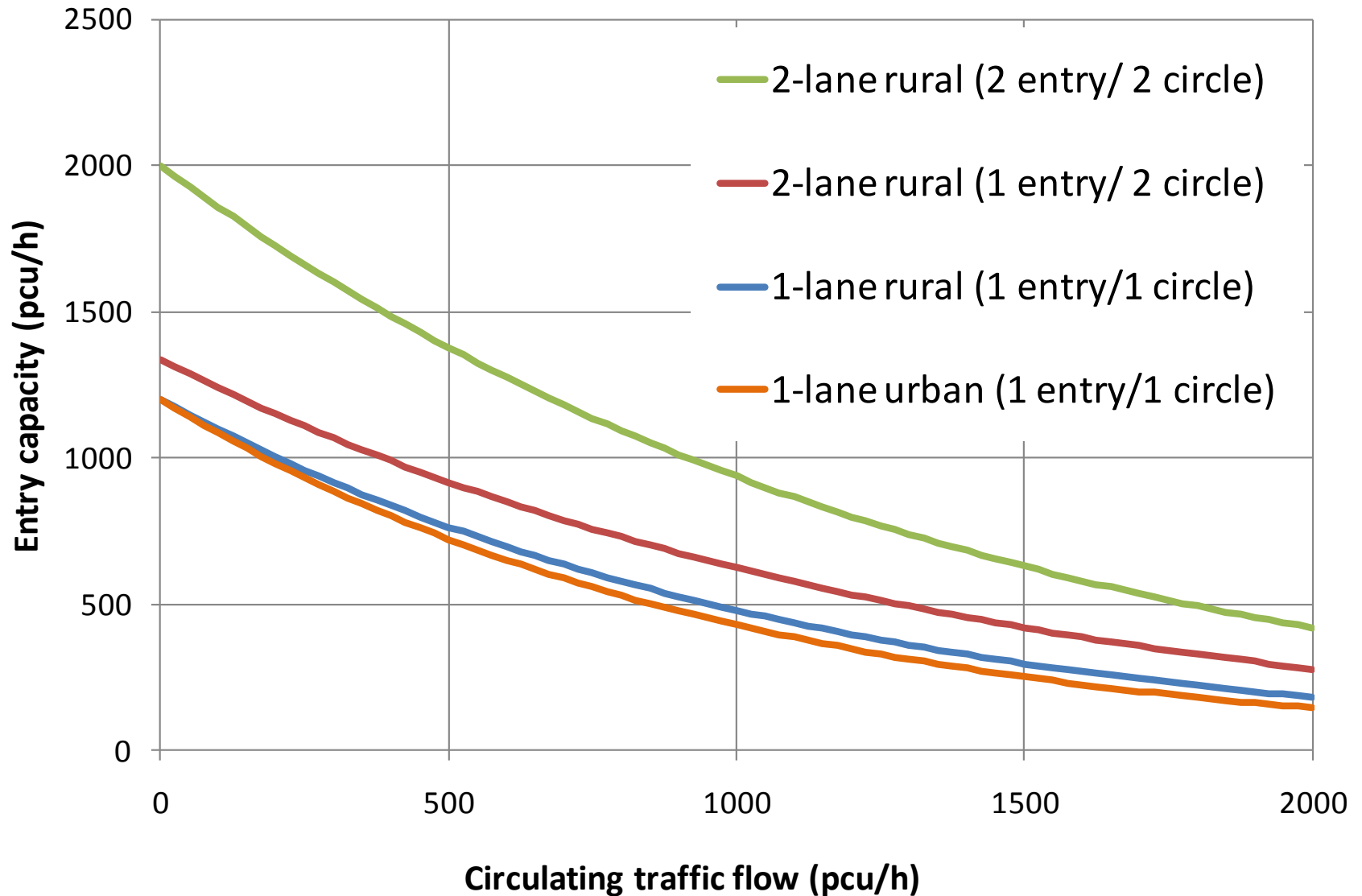Entry capacity as a function of circulating and exiting flow

Danish Capacity Manual

Type		Critical gap (tg)		Follow up time (tf)
		Car	Cyclist	
1-lane	Urban	5.1 sec	2.5 sec	3.0 sec
1-lane	Rural	4.7 sec	2.5 sec	3.0 sec
2-lane	Rural	4.0 sec	-	2.6 sec

	Qe (exiting flow)	k (reduction factor)
1 - lane	0-400 pc/h	1.00
	400-600 pc/h	0.90
	> 600 pc/h	0.85
2-lane	0-400 pc/h	1.00
	400-800 pc/h	0.95
	>800 pc/h	0.90

Entry capacity - different lane configurations

Legend:
- 2-lane rural (2 entry/ 2 circle)
- 2-lane rural (1 entry/ 2 circle)
- 1-lane rural (1 entry/1 circle)
- 1-lane urban (1 entry/1 circle)

Y-axis: Entry capacity (pcu/h)
X-axis: Circulating traffic flow (pcu/h)

Signing, marking and lane use

Lane use
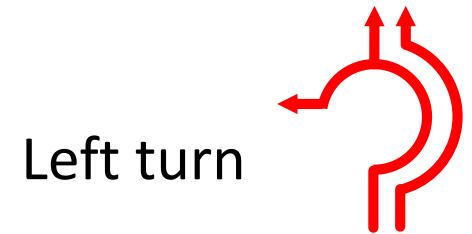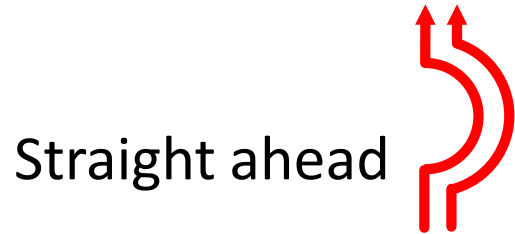
	Straight ahead	Left turn
Right entry lane	50-90%	Approx: 5%
Left entry lane	10-50%	Approx: 95%

Thank you for your attention !