

TURBO ROUNDABOUTS

WELCOME

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WELKOM

30 april 2020



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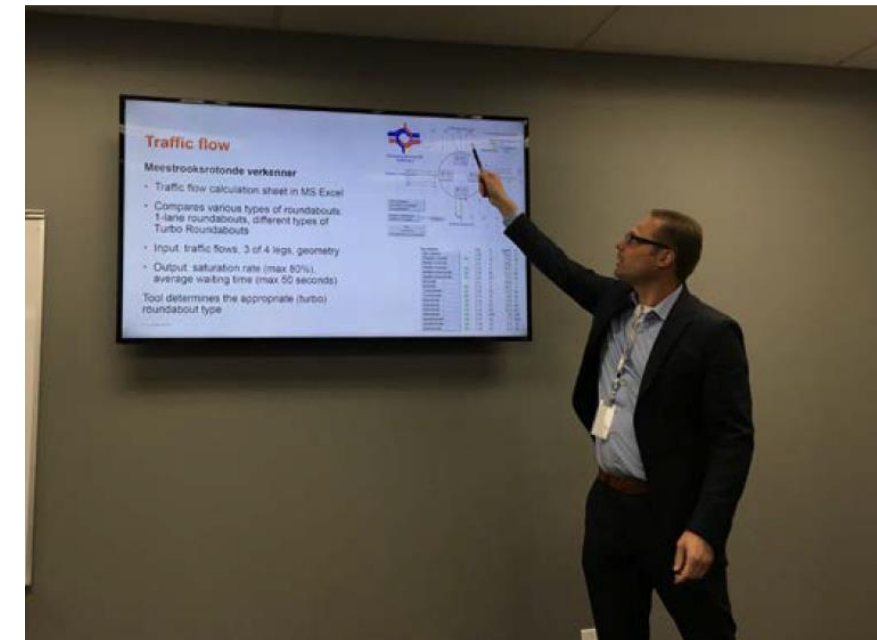
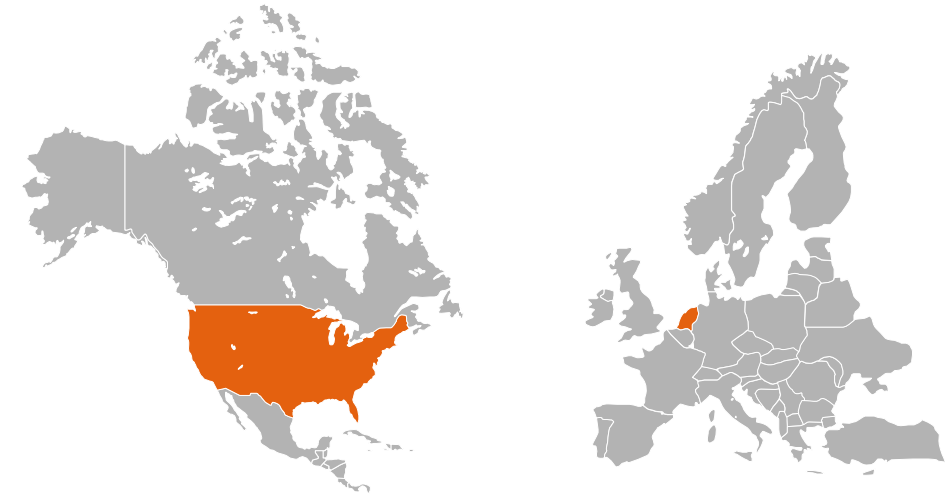


Introduction

Jaap Tigelaar

- Born and raised in the Netherlands.
- Master of Science at the Delft University of Technology.
- Joined Arcadis Netherlands already in 2008.

- Quest to the US in 2018 to introduce the Turbo Roundabout.
- Moved to Arcadis US February 2019.
- Located at our Atlanta office.



Introduction

Evolution of the Roundabouts in the US

Why Turbo Roundabouts

History Turbo Roundabouts

Looks and Feel

Design Aspects

Traffic Flows and Capacity

Attentions to special users

Implementation in the US

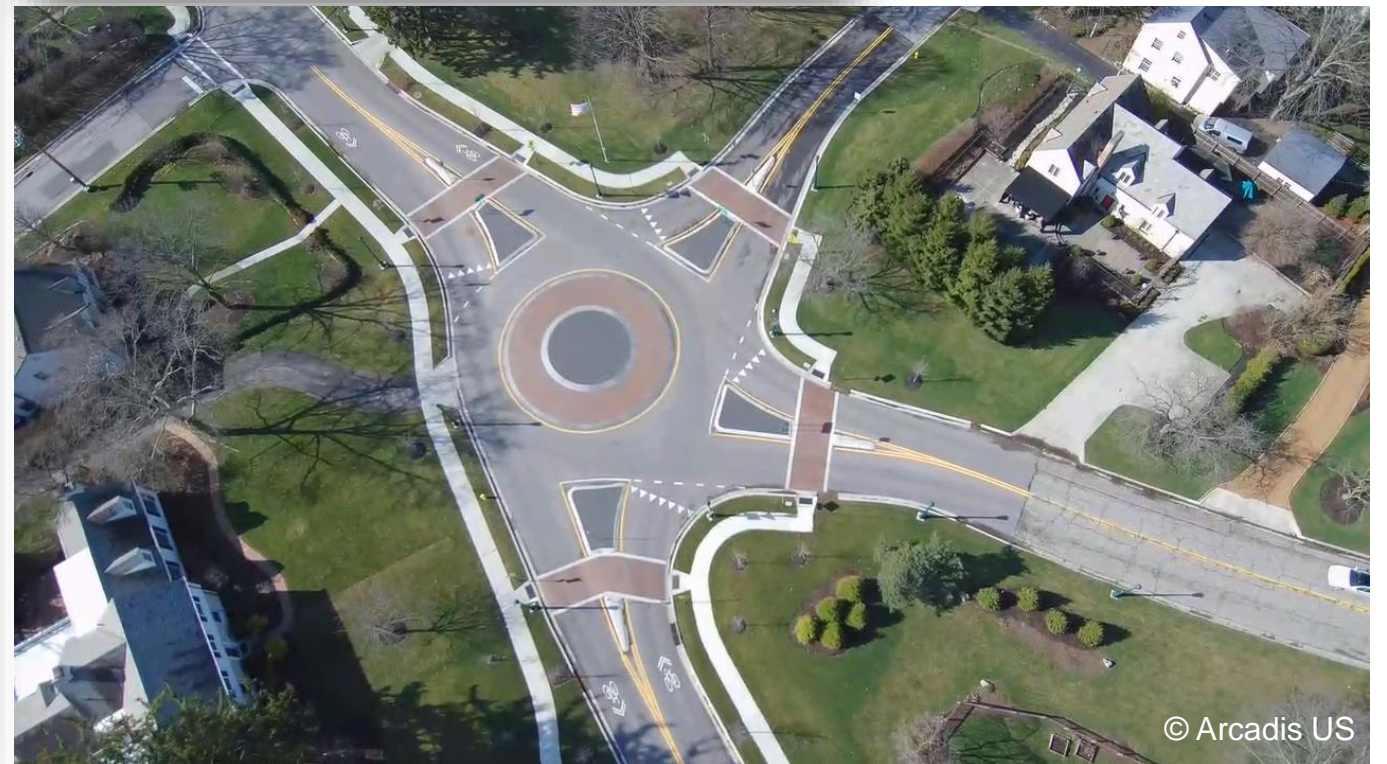
Questions and Discussion

Get into the Roundabout

Evolution of Roundabouts US



Compact (Mini)



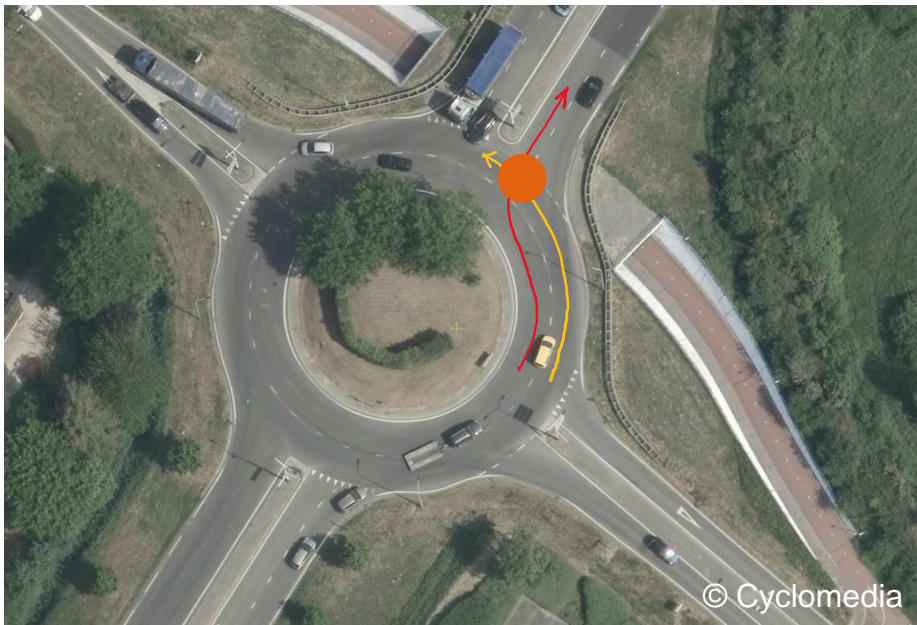
What next?



Why Turbo Roundabouts?

Why Turbo Roundabouts?

- Single lane roundabouts introduced in the eighties in the Netherlands
- With the increase of traffic volumes, single lane roundabouts replaced by multilane roundabouts
- Standard multilane roundabout has safety issues: weaving conflicts



Why Turbo Roundabouts?



Why Turbo Roundabouts?

- **Challenge:** design a layout which eliminates the safety conflicts and increases capacity
- **Result:** spiral shaped Turbo Roundabout without lane changing on the roundabout
- **Why the name Turbo Roundabout?** Refers to the improved traffic flow (compared to a standard multilane roundabout)



Why Turbo Roundabouts?

Turbo Roundabout characteristics:

No lane changing

Lane choice upstream

Spiral layout

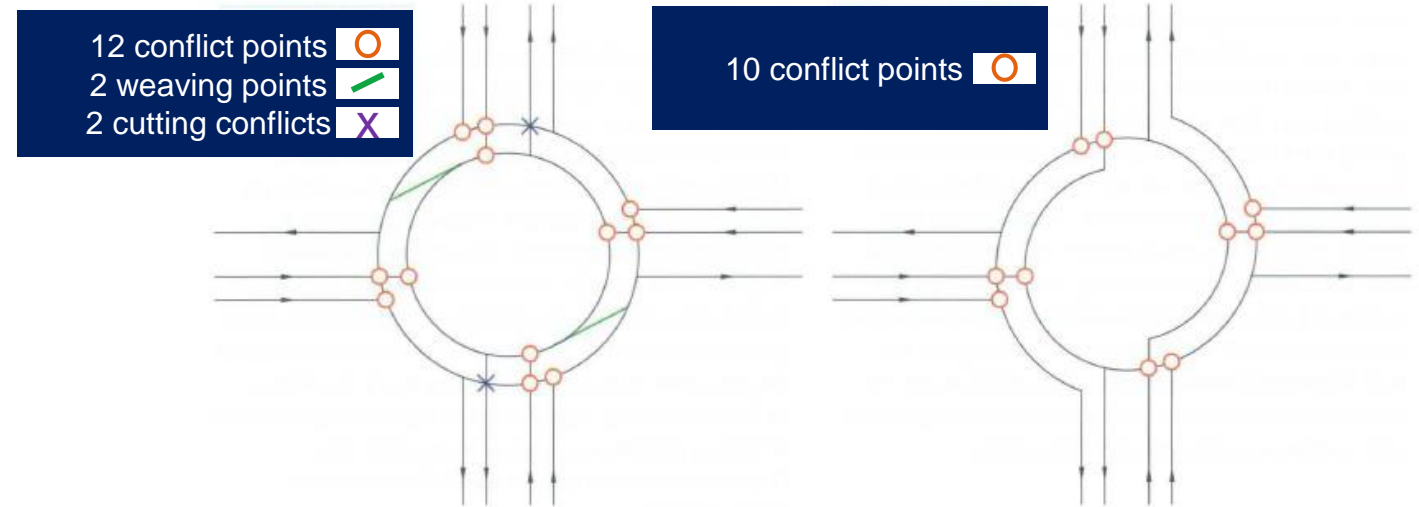
Radial approaches



Why Turbo Roundabouts?

Turbo Roundabout reduces the number of conflict points

- 16 vs 10 conflict points
- Reduction of 37.5%



© CROW Guideline: turborotondes

Evaluation Study

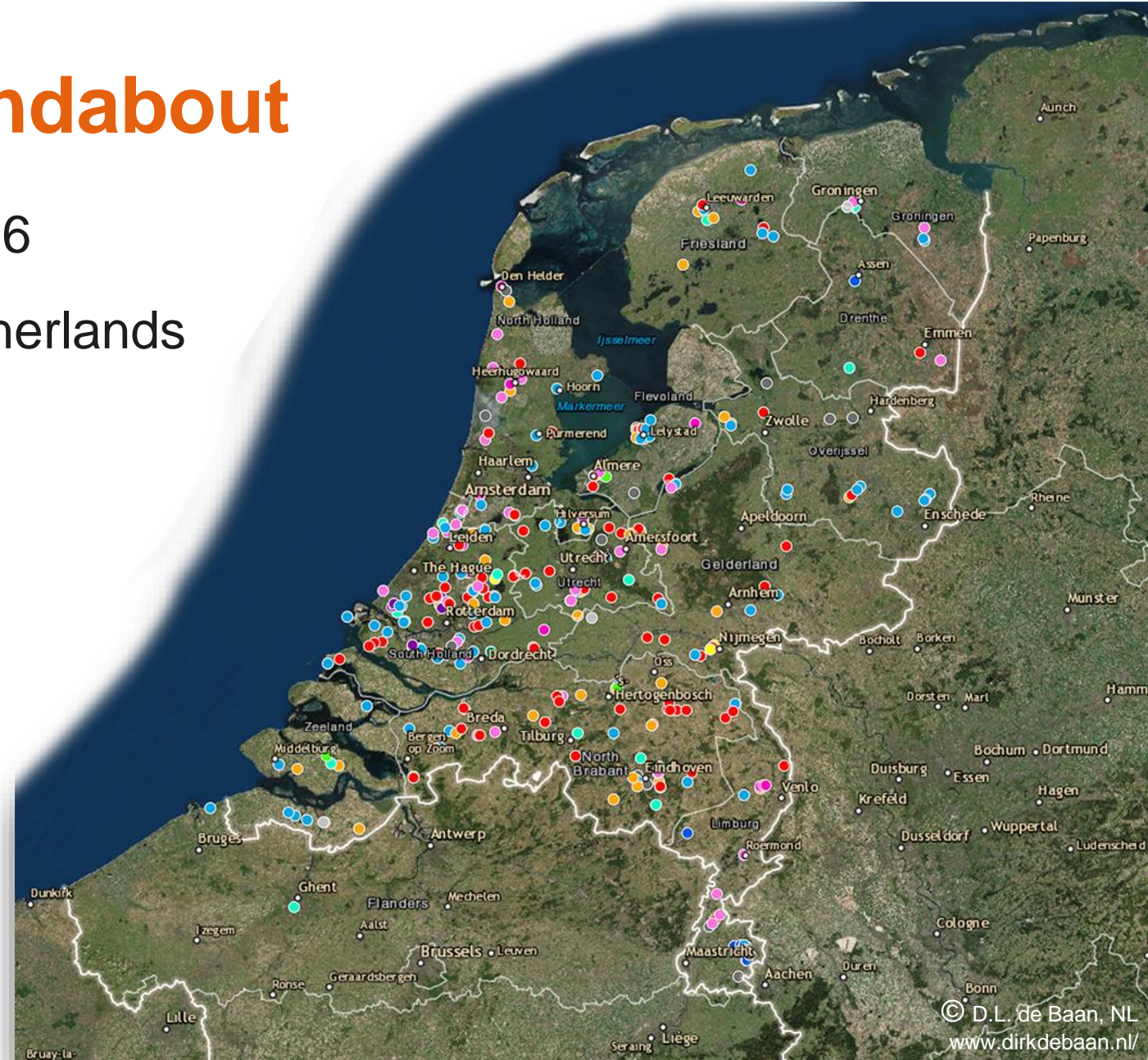
- 2016 study by Christiaan Vos
- Over 50% reduction crashes

| From | n | before | after | reduction |
|-------------------|-----------|-----------|----------|-------------|
| Unsignalized | 54 | 76 | 19 | -75% |
| Signalized | 46 | 73 | 19 | -74% |
| Multi Lane | 17 | 17 | 8 | -53% |
| Single Lane | 26 | 18 | 7 | -61% |

History of Turbo Roundabout

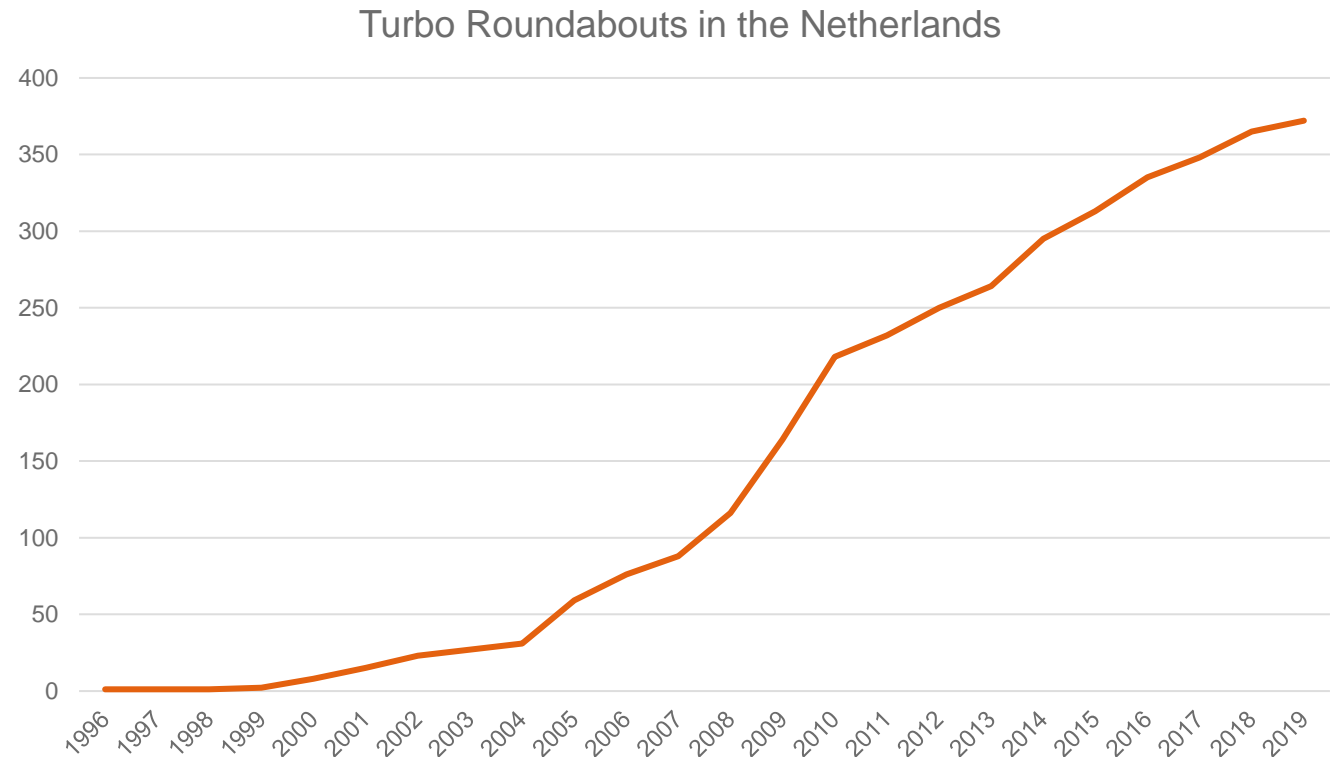
History of Turbo Roundabout

- Invented by Bertus Fortuijn in 1996
- 372 turbo roundabouts in the Netherlands
- 225 outside the Netherlands



History of Turbo Roundabout

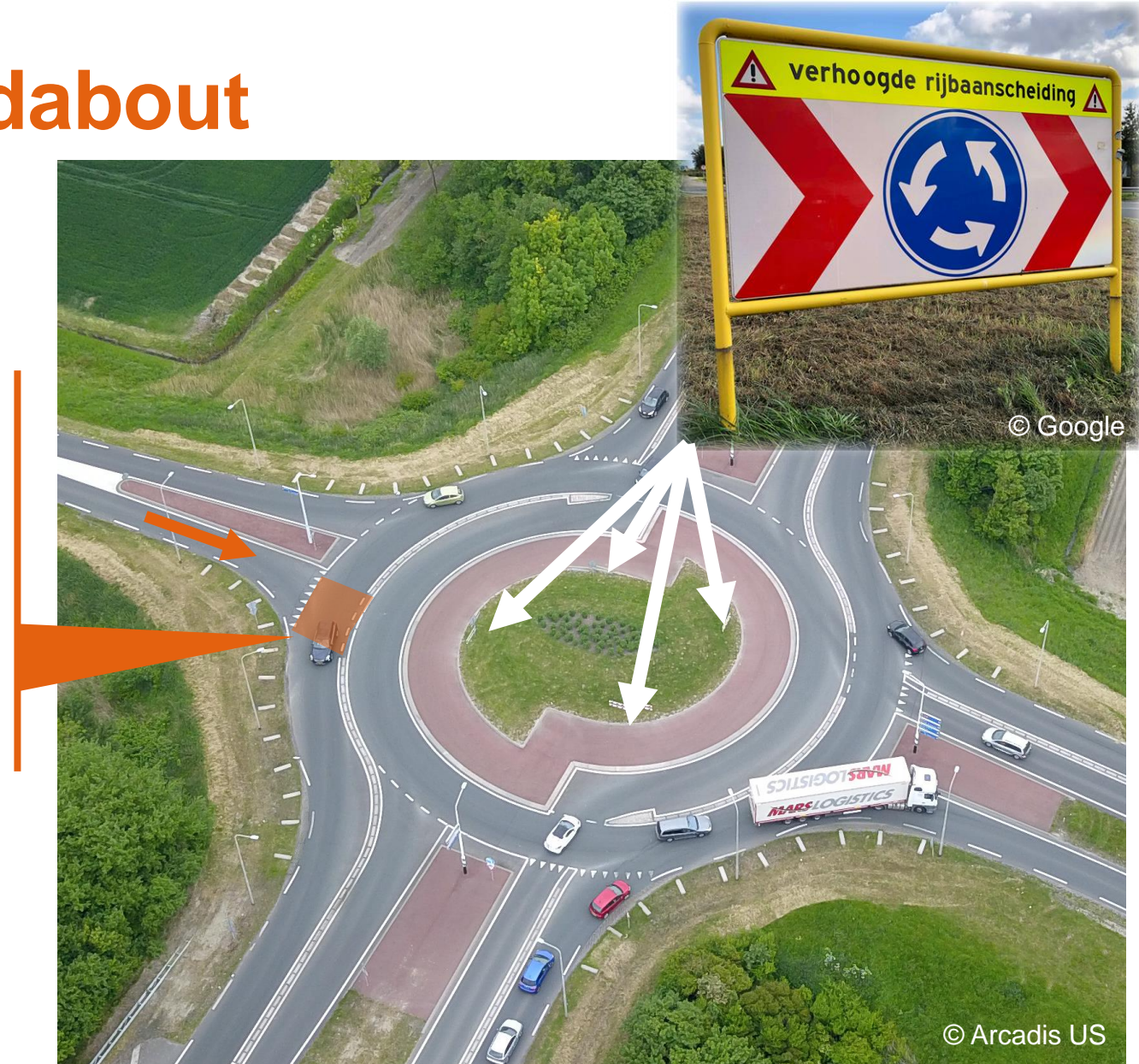
- First few years slow
- After proven success it really started
- In 2004 first in Germany
- Other countries in Eastern Europe
- Outside Europe only South-Africa and Canada



History of Turbo Roundabout

Fortuijn's Design philosophy

- A safe design by geometry
- Radial design results in:
 - Short crossing distance to the middle lane of the Turbo Roundabout
 - Small conflict area
 - Good sight lines (don't need to look over the shoulder)
- Low speeds on the Turbo Roundabout and a short crossing distance are also beneficial for capacity!
- Signage in front of driver is important

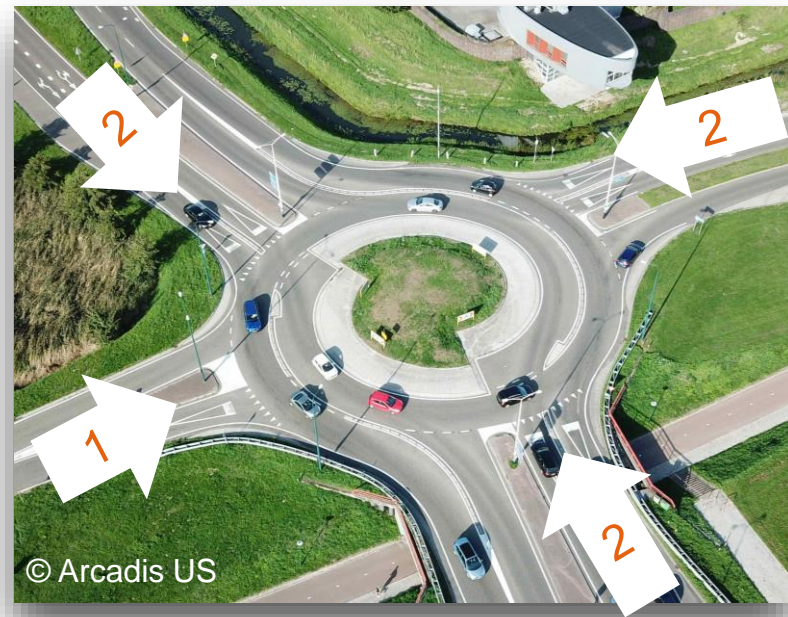


Looks

Looks

Number of entry lanes

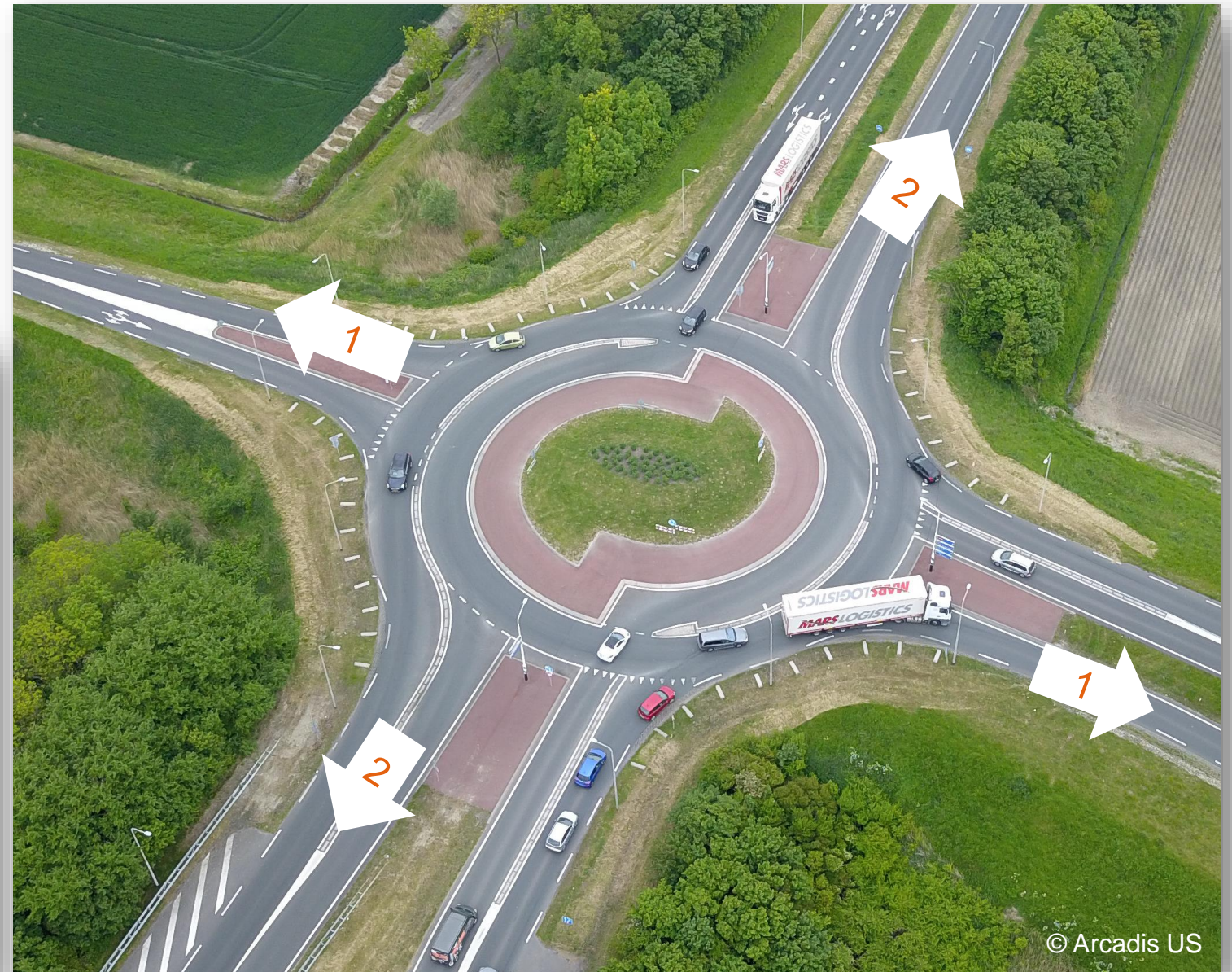
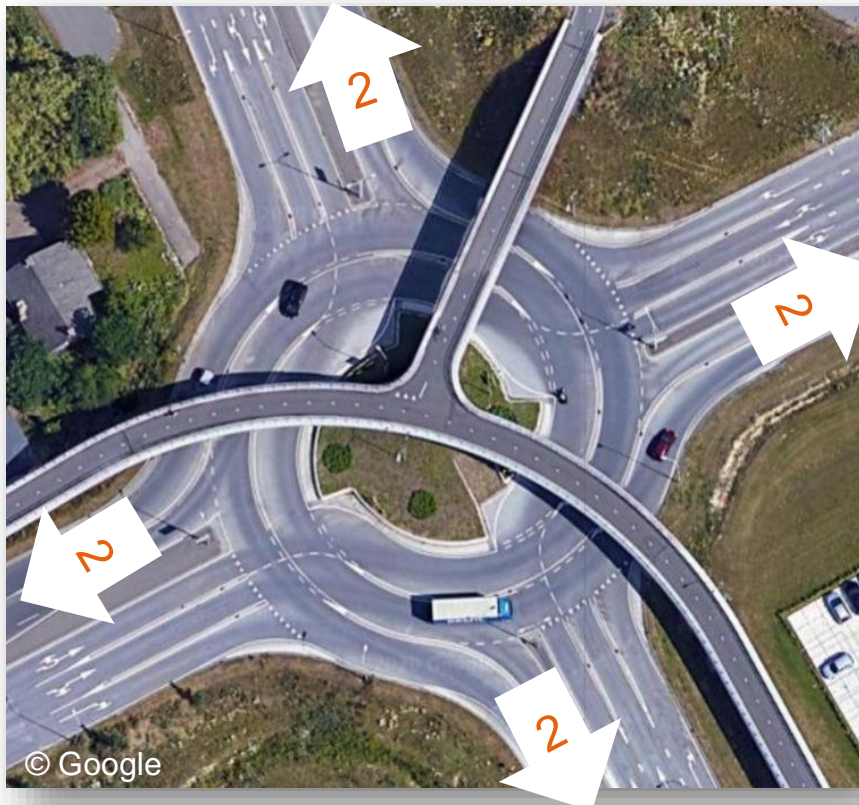
- One or two
- Or many (signalized)



Looks

Number of exit lanes

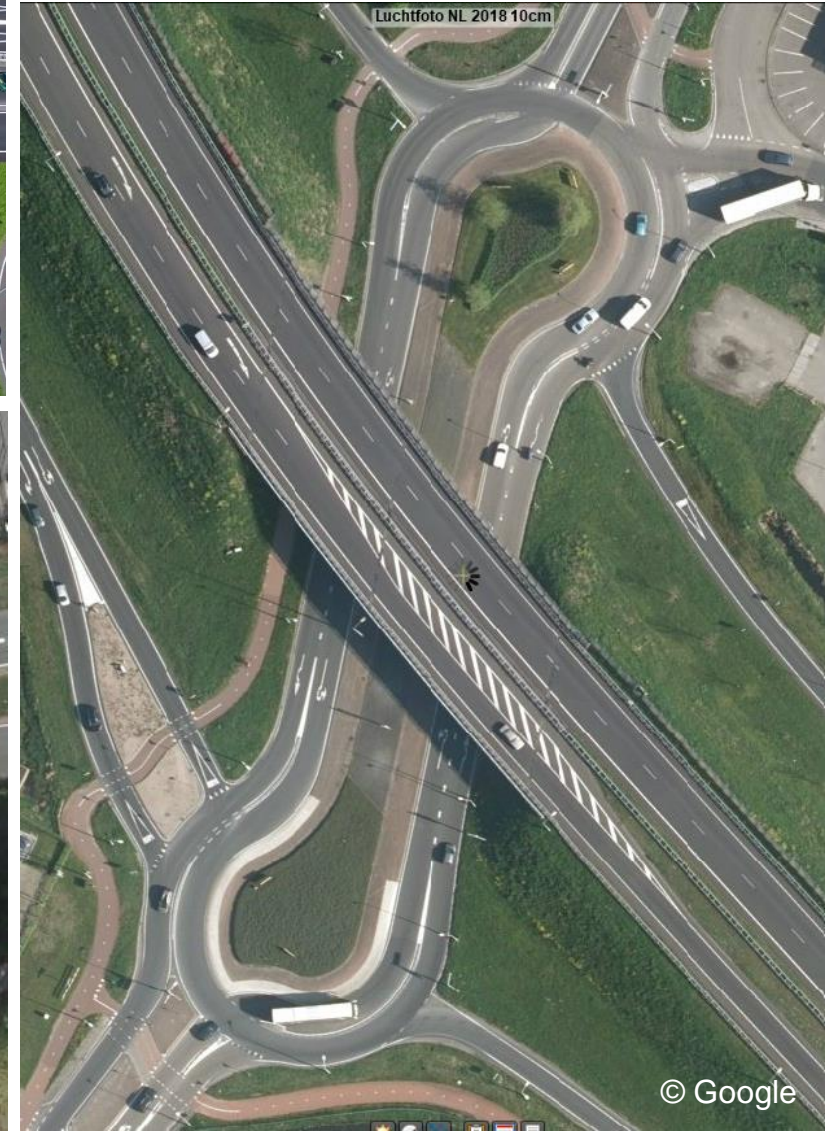
- One or two



Looks

Special Shapes

- Angles
- Oval
- Peanut / dog bone



Let's take a drive



Design

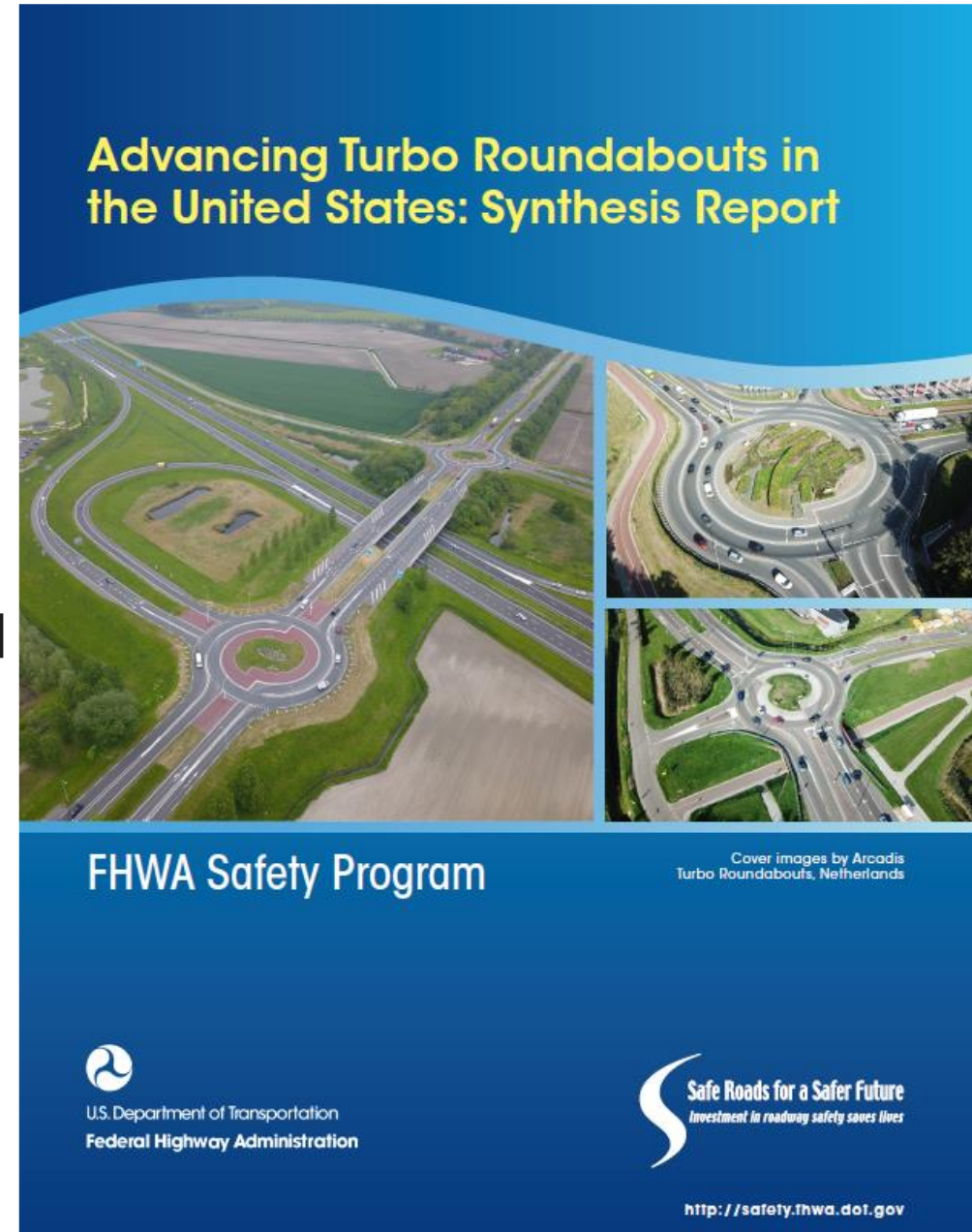
Design – Guidelines

- Design criteria incorporated in the Dutch national guideline for Turbo Roundabouts:
CROW publication 257
- Based on Fortuijn's design principles



Design – Guidelines

- FHWA is working on Turbo Roundabout publications.
- First: Advancing Turbo Roundabouts in the United States.
 - Exploration what there is to know in the world
- Next: Technical Summary
 - Turbo Roundabout in US Context.
- Arcadis is helping FHWA



Design – Spiral

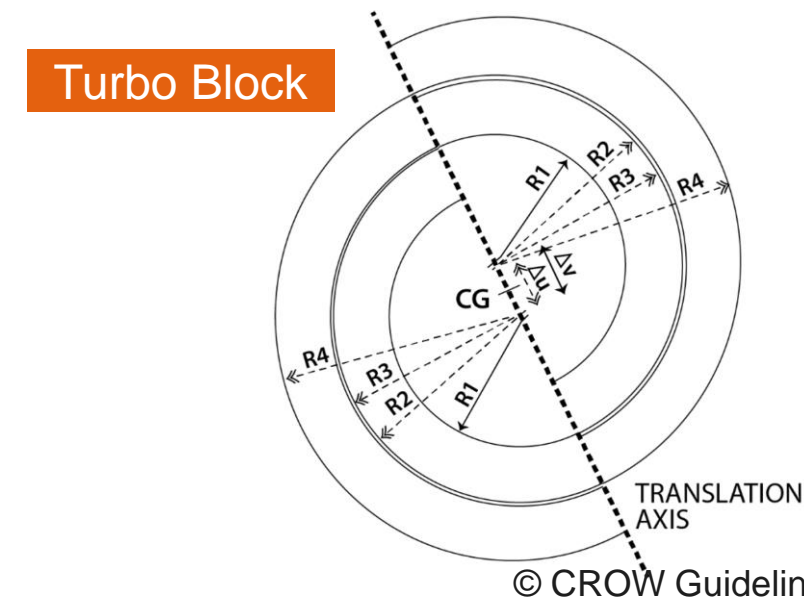
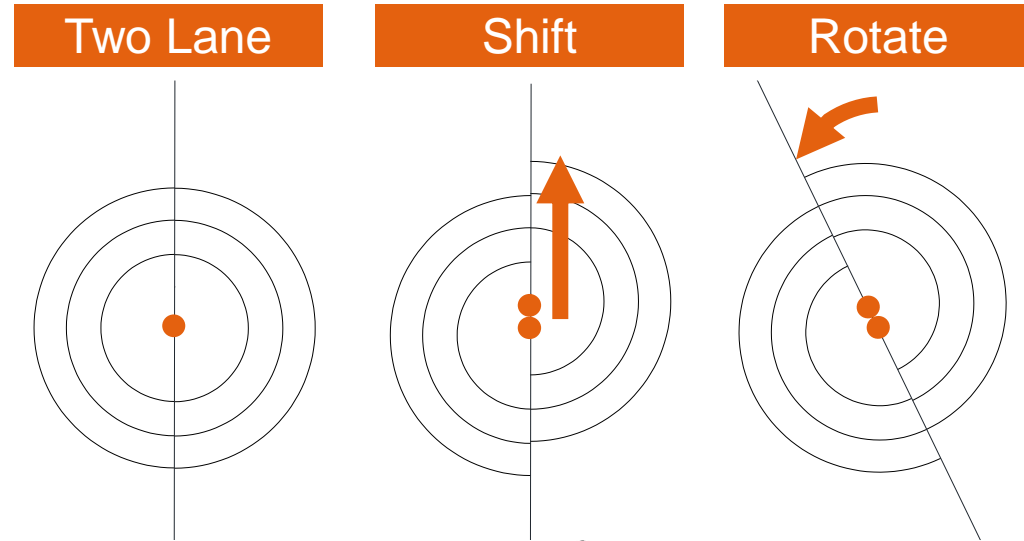
Create a spiral

1. Two lane roundabout
2. Shift center a lane
3. Rotate

Translation axis:

- Based on the major approaches
- Similar curvature all through traffic

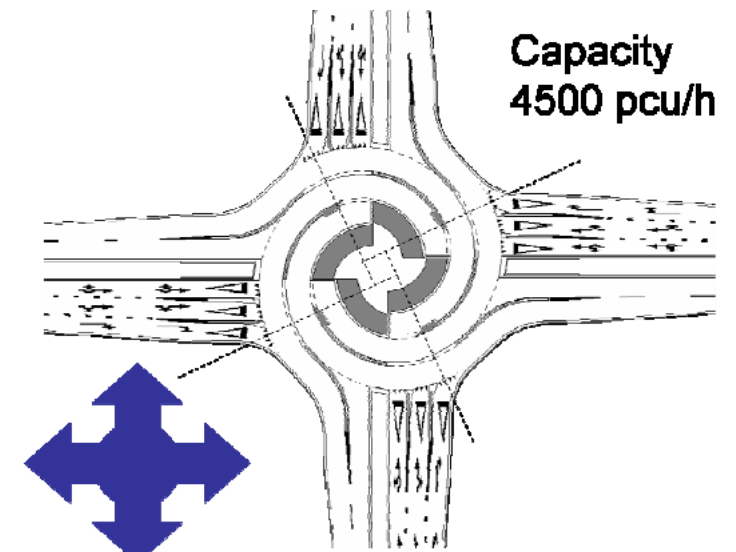
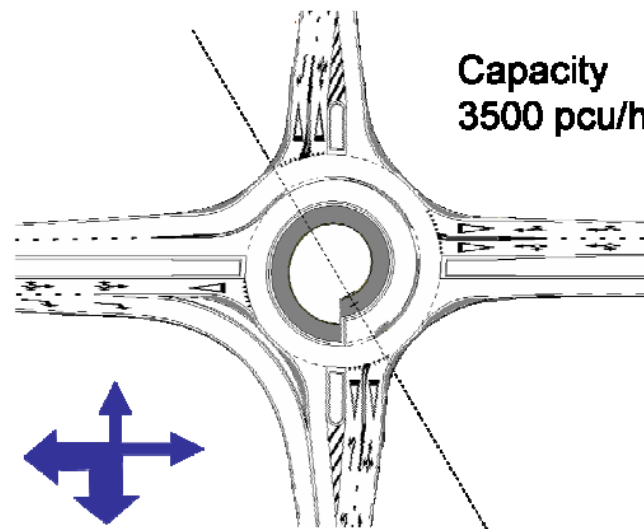
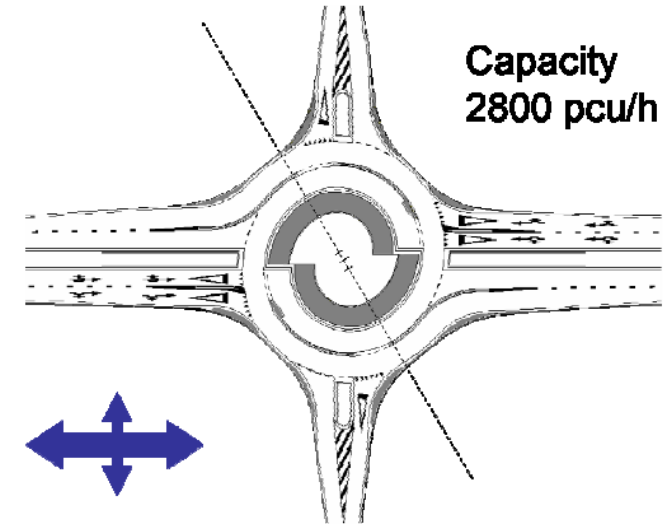
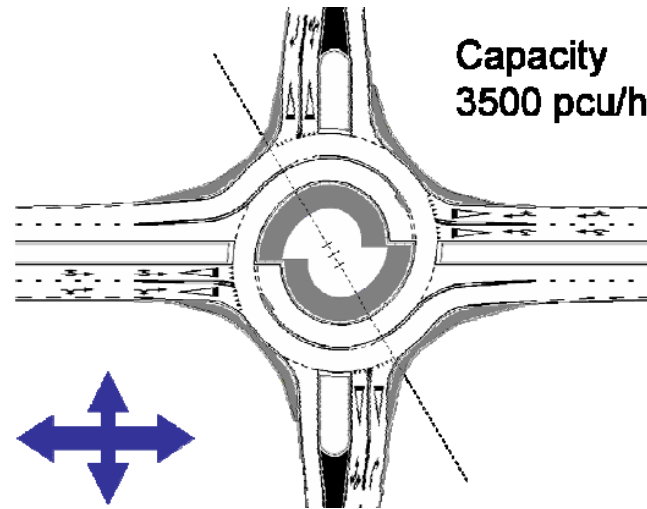
“Turbo-Block”



Design – Turbo Block

Types

- Several standard shapes
- Variation in lanes
- Suitable for different locations

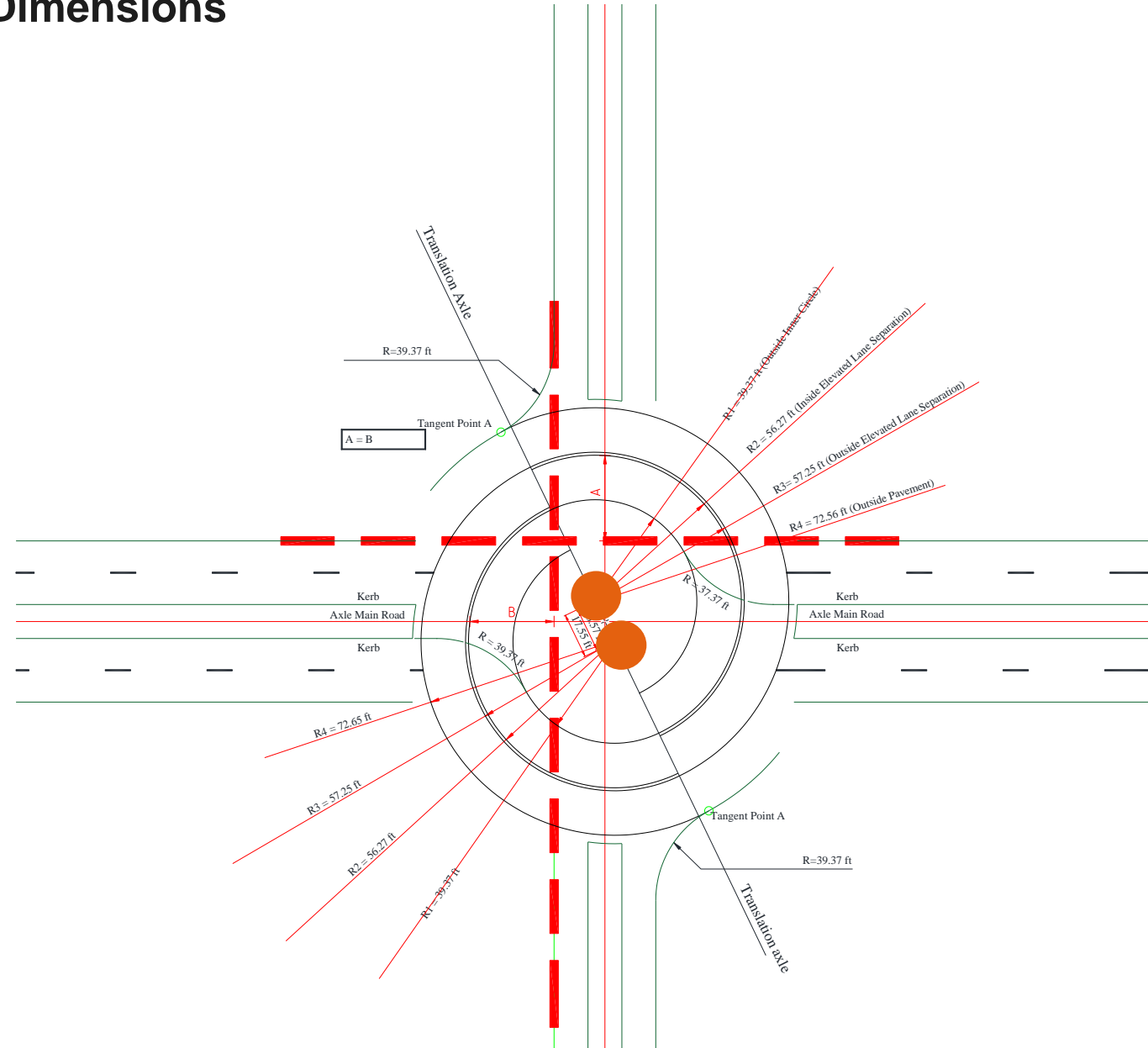


Dimensions

Design – Size

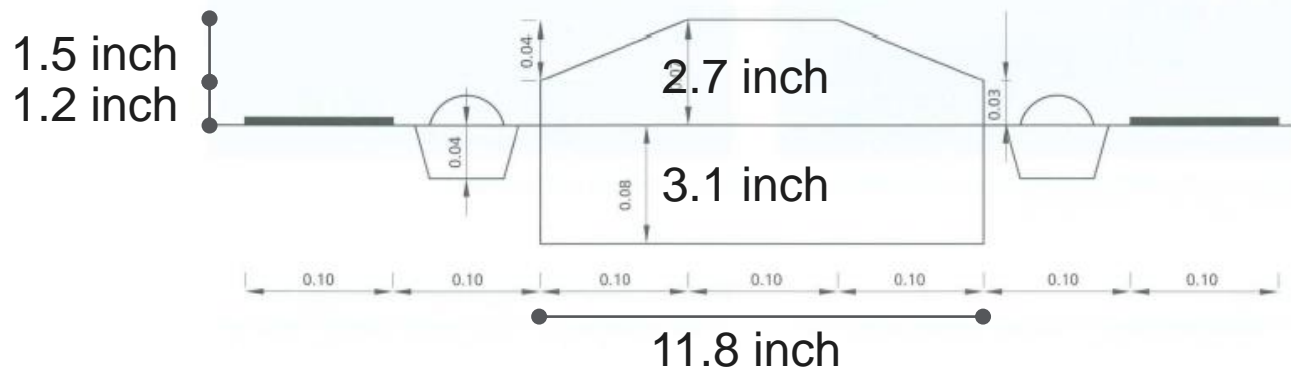
- Dependent on:
 - Number of lanes
 - Design vehicle
- Typically design speeds between 23 and 25-mph

| | Small | Standard | Large |
|---------------------------------|---------|----------------|---------|
| Radius Inner | 34.5 ft | 39.4 ft | 65.5 ft |
| Outer diameter (min and max) | 140 ft | 148 ft | 197 ft |
| | 155 ft | 165 ft | 213 ft |



Design – Lane Separation

- Elevated separation
- Discomfort high speed / ‘comfort’ low speed
- 2.7 inch height and 11.8 inch wide
- 3.1 inch in the pavement



Design – Opening Width



Keep it WIDE !!

Design – Opening Width



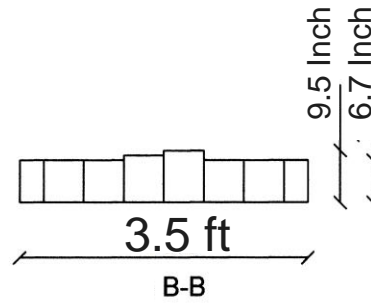
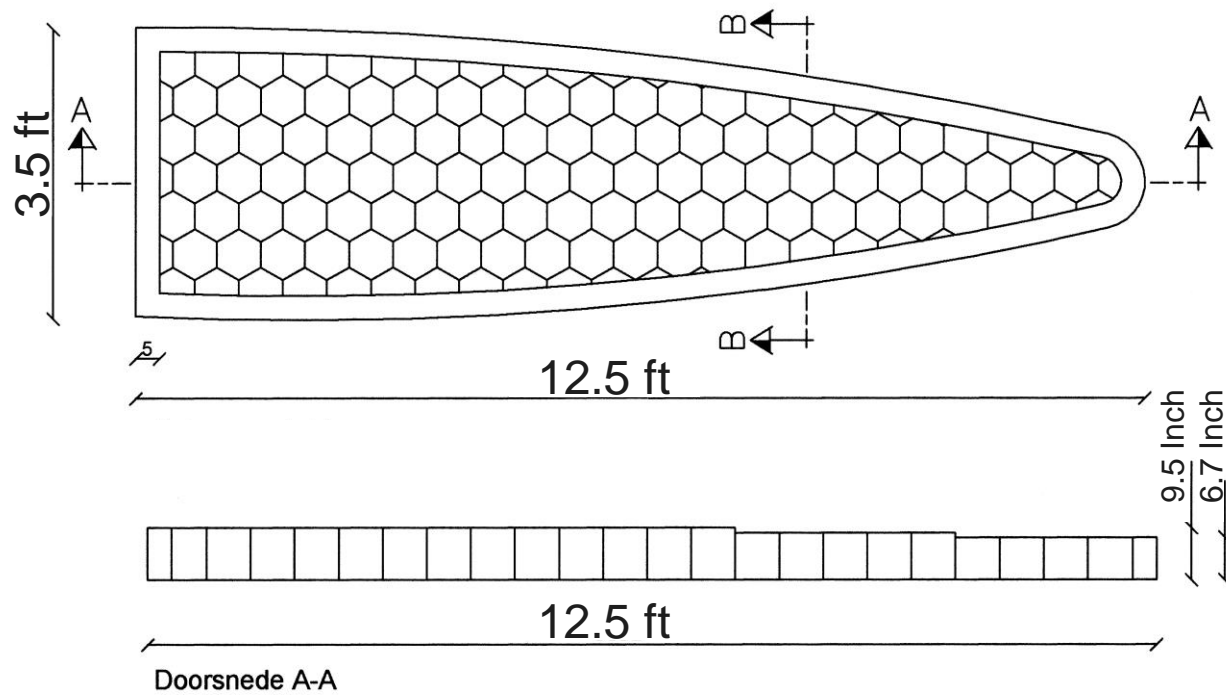
Design – Opening Width



FROG

Start of the curb

Design – “The Frog”



Design – Marking and Signage

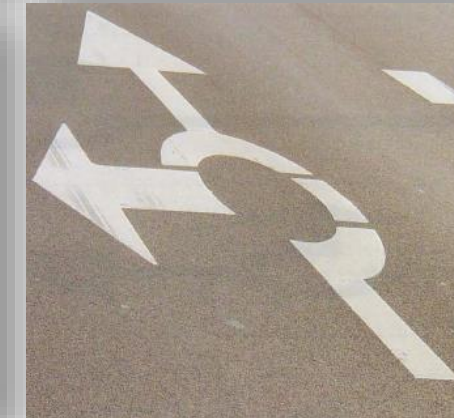
Upstream

- Clear directions with destinations
- If possible, above the lanes
- Directions on the pavement



On the roundabout

- No arrows on pavement
- Signs with destinations at exit



Design – Signalized

- Signalized Turbo Roundabouts
- High volumes
- Diameter 360 ft



Traffic Flows

Traffic flow

Capacity of intersection alternatives

Practical capacity (sum of all approaches)

Theoretical capacity (sum of all approaches)

Entering and conflicting volumes

1-lane roundabout

2-lane roundabout

Turbo Roundabout

(Signalized) intersections

Tabel III.1. Praktische en theoretische capaciteit van verschillende kruispuntvormen [14, 31]

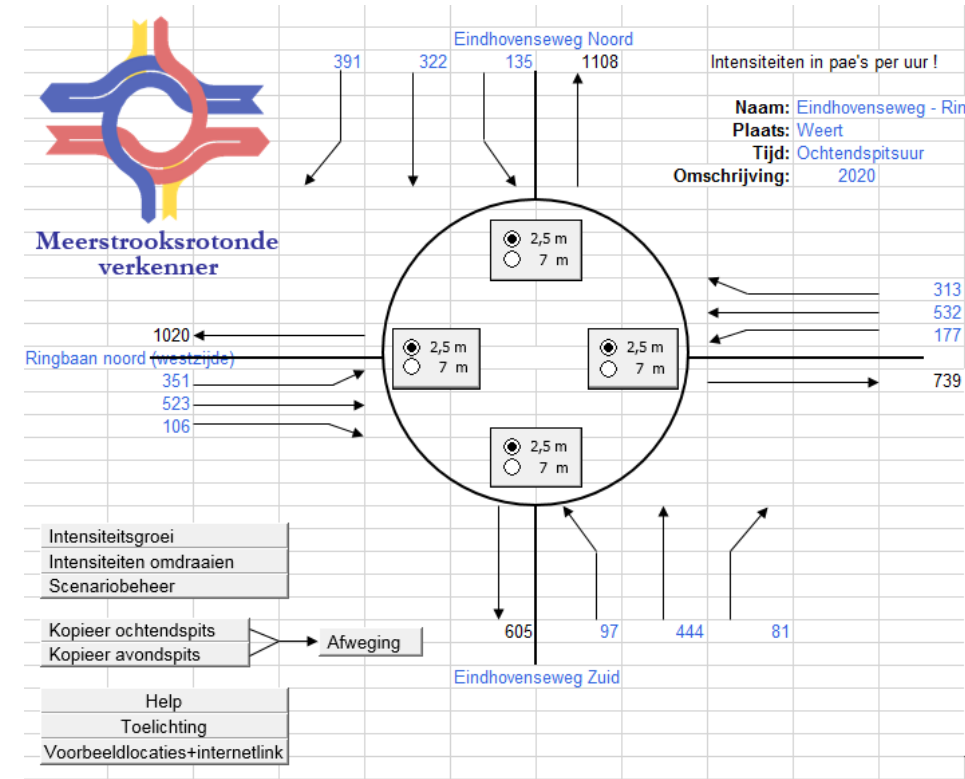
| Kruispuntvorm | Capaciteit in stroom van alle toeritten samen in mvt/h (~10% van de etmaalcapaciteit) | | Maatgevende conflictbelasting toerit + rotondetak, in pae/h |
|--|---|-------------|---|
| | praktisch | theoretisch | |
| Enkelstrooksrotonde | 2.000 | 2.700 | 1.100 - 1.500 |
| Tweestrooksrotonde met eenstrookstoeritten en -afritten | 2.200 | 3.600 | 1.500 - 1.800 |
| Tweestrooksrotonde met tweestrookstoeritten en eenstrooks-afritten | 3.000 | 3.600 | 1.800 - 2.000 |
| Tweestrooksrotonde met tweestrookstoeritten en -afritter | 3.500 | 4.000 | 2.100 - 2.400 |
| Turborotonde basisvorm (zie figuur 12) | 3.500 | 3.800 | 1.900 - 2.100 |
| Spiraalrotonde (zie figuur 12) | 4.000 | 4.300 | 2.000 - 2.300 |
| Rotorrotonde (driestrookstoeritten, tweestrooks-afritten, zie figuur 12) | 4.500 | 5.000 | 2.500 - 2.800 |
| Turboverkeersplein (per toevoertak 3 × 2 rijstroken, zie hoofdstuk 7) | 8.500 | 11.000 | 4.200 |
| Voorrangskruispunt (met eventueel linksafvakken) | 1.500 | 1.800 | 1.100 |
| Viertakskruispunt met VRI (per toevoertak 3 × 1 rijstrook) | 3.500 | 4.000 | 3.800 |
| Viertakskruispunt met VRI (per toevoertak 3 × 2 rijstroken) | 7.500 | 8.000 | 3.800 |

Traffic flow

Meestrooksrotonde verkenner

- Traffic flow calculation sheet in MS Excel
- Compares various types of roundabouts: 1-lane roundabouts, different types of Turbo Roundabouts
- Input: traffic flows, 3 or 4 legs, geometry
- Output: saturation rate (max 80%), average waiting time (max 50 seconds)

Tool determines the appropriate (turbo) roundabout type



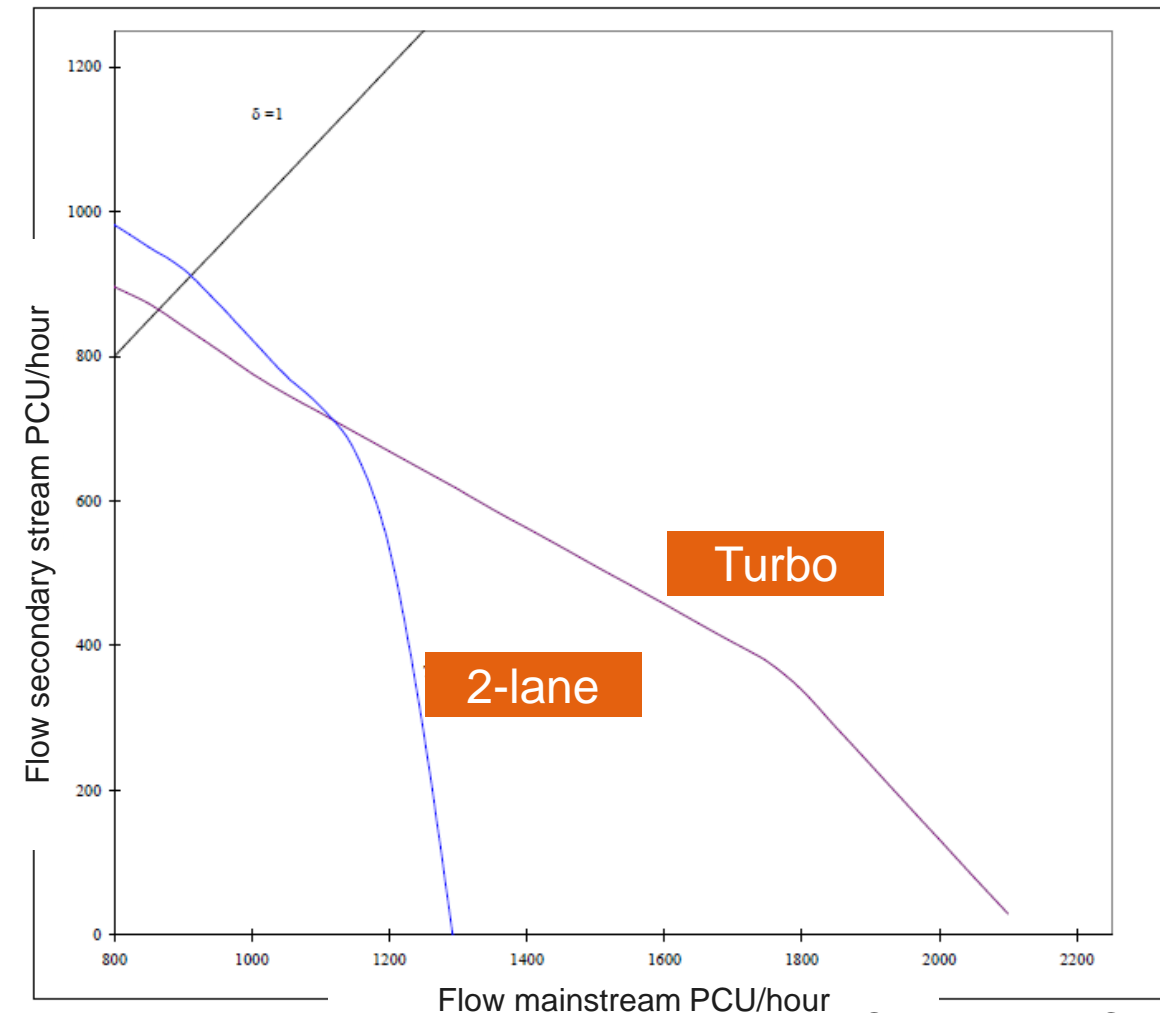
| Resultaten | | VG | ri. | Tgem | ri. |
|--------------------------|----|------|-----|------|-----|
| 1str. rotonde | | 0,90 | O | 32,9 | O |
| Passeerb. rotonde | OK | 0,65 | W | 11,4 | W |
| Partiële eirotonde | | 0,91 | O | 39,6 | O |
| Partiële eirotonde -- | OK | 0,75 | N | 15,5 | N |
| Partiële turborotonde | OK | 0,68 | WL | 13,0 | WL |
| Partiële turborotonde -- | OK | 0,60 | OR | 8,2 | NL |
| Eirotonde | | 0,91 | O | 39,6 | O |
| Eirotonde -- | OK | 0,76 | N | 16,3 | N |
| Turborotonde | OK | 0,68 | WL | 13,0 | WL |
| Turborotonde -- | OK | 0,53 | NL | 8,4 | NL |
| Knierotonde ' - | OK | 0,40 | OL | 6,6 | ZL |
| Knierotonde ' - | OK | 0,70 | WL | 14,2 | WL |
| Knierotonde ' - | OK | 0,63 | WL | 10,3 | WL |
| Knierotonde ' - | OK | 0,48 | WR | 7,2 | WR |
| Spiraalrotonde | OK | 0,47 | NL | 7,1 | WM |
| Spiraalrotonde -- | OK | 0,39 | OL | 6,2 | ZL |
| Rotorrotonde | OK | 0,46 | NL | 6,4 | NL |

Traffic flow

Comparison:

Turbo Roundabout vs Standard Two-Lane Roundabout

- Turbo Roundabout has higher capacity in situations where volume on **main** road is larger than volume on **secondary** road
- Better lane utilization
- Traffic entering are less hesitant
- Radial approach



Special attention to special users

Bikes

In the Netherlands

- 23,000,000 bikes
- 1.3 bikes a person
- 27% of all trips



Bikes

Bike Safety

- Reduce differences in mass, speed and direction
- Separate facilities
- Shared at low speeds



Bikes

Recommendations at Roundabouts

- Separate facilities
 - Bike Lane
 - Bike Path (Safer)
- Within City Limits: Bikes right of way
- Outside City: Bikes must yield



Bikes

At Turbo Roundabouts

- Crossing multiple lanes
- Stop in median (preferred S-Shaped)
- Grade Separated



Bikes



© Arcadis-US



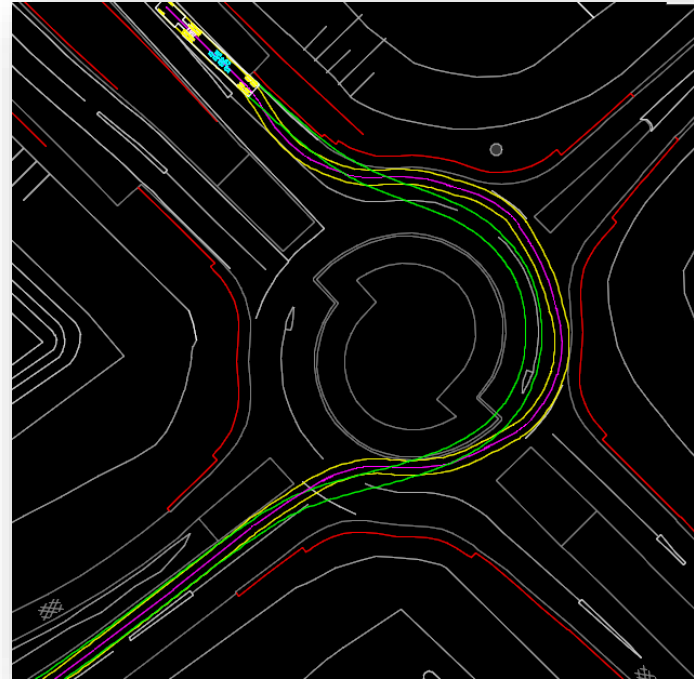
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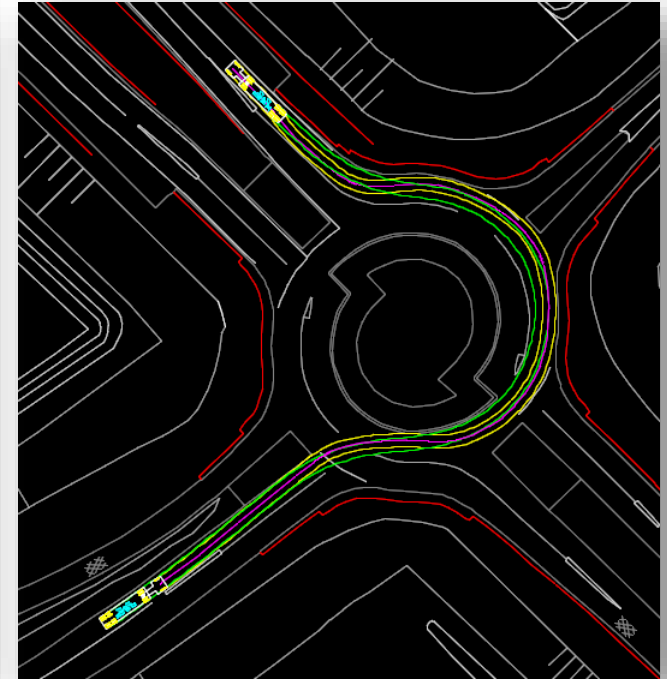
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Trucks

- Typical Dutch truck ~WB-50
- WB-62 truck through a Dutch roundabout (standard / regular 165' diameter)
 - WB-40 works well
 - WB-62 requires a slightly larger diameter (180'-190')



WB-62



WB-40

Trucks

- This truck: 82.8 ft
- Roundabout: 190 ft
- Left Turn



Motorcycles

The elevated lane separation not ideal for motorcycles but:

The smaller change that drivers unexpectedly make a lane change, outweighs the risk of hitting the elevated lane separation.

Essential for bikers:

- Warning signs upstream of the turbo roundabout (150 ft)
- Repeat warning signs at center island
- Not too high: 7 cm height (2.7 inch)
- Use contrasting colors



Motorcycles



Verhoogde rijbaanscheiding

=

Elevated Lane Separation

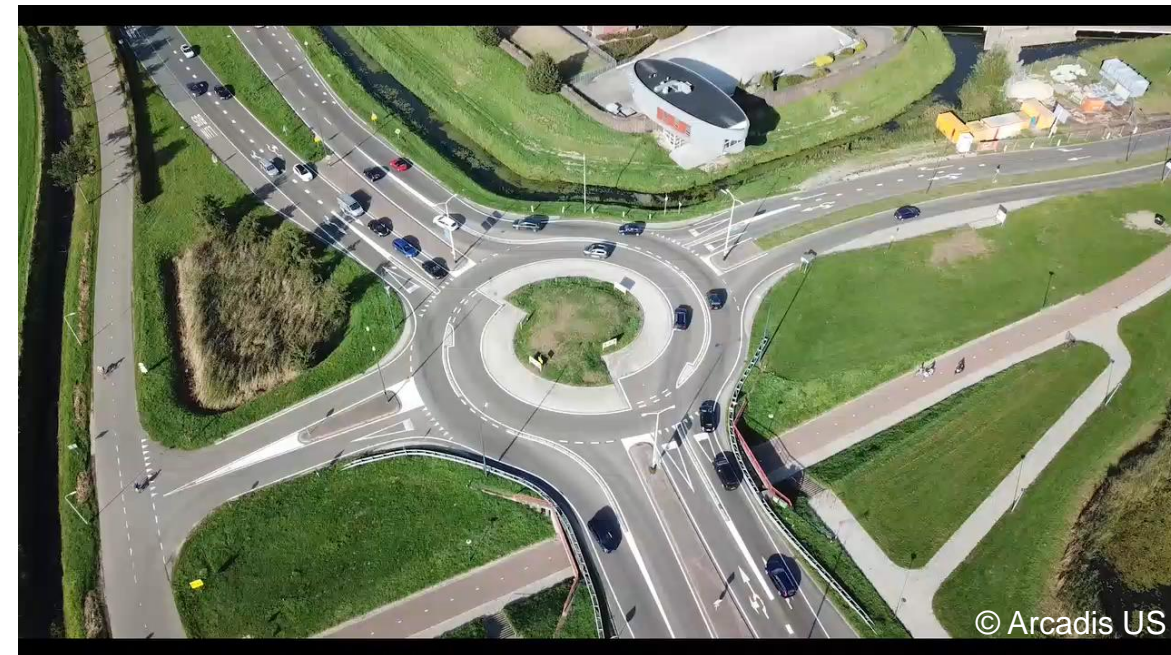


Turbo Roundabout in the US

Turbo Roundabout in US

Steps for implementing in the US:

- Minor adjustments to fit US design vehicles
- Calibration and validation of US driving behavior (calculation sheet and simulation)
- Look at specific conditions (Drainage, etc.)
- Introduction of the concept: understanding of the concept by the drivers
- Monitoring and evaluation of driving behavior, traffic safety and traffic flow (capacity)
- Start with a simple turbo roundabout or aspects of it (lane separation)



Turbo Roundabout in US

- Jacksonville (FL)
- Ohio



Questions – Discussion?



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