WELCOME
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TURBO ROUNDBOUTS

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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

Attention to special users

Implementation in the US

Questions and Discussion
Get into the Roundabout
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%

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

<table>
<thead>
<tr>
<th>From</th>
<th>n</th>
<th>before</th>
<th>after</th>
<th>reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsignalized</td>
<td>54</td>
<td>76</td>
<td>19</td>
<td>-75%</td>
</tr>
<tr>
<td>Signalized</td>
<td>46</td>
<td>73</td>
<td>19</td>
<td>-74%</td>
</tr>
<tr>
<td>Multi Lane</td>
<td>17</td>
<td>17</td>
<td>8</td>
<td>-53%</td>
</tr>
<tr>
<td>Single Lane</td>
<td>26</td>
<td>18</td>
<td>7</td>
<td>-61%</td>
</tr>
</tbody>
</table>
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:
  o Short crossing distance to the middle lane of the Turbo Roundabout
  o Small conflict area
  o 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 trough traffic

“Turbo-Block”
Design – Turbo Block

Types

- Several standard shapes
- Variation in lanes
- Suitable for different locations
Design – Size

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

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Standard</th>
<th>Large</th>
</tr>
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<tbody>
<tr>
<td>Radius Inner</td>
<td>34.5 ft</td>
<td><strong>39.4 ft</strong></td>
<td>65.5 ft</td>
</tr>
<tr>
<td>Outer diameter</td>
<td>140 ft</td>
<td><strong>148 ft</strong></td>
<td>197 ft</td>
</tr>
<tr>
<td>(min and max)</td>
<td>155 ft</td>
<td><strong>165 ft</strong></td>
<td>213 ft</td>
</tr>
</tbody>
</table>
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

Keep it NARROW !!
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

© CROW Guideline: turborotondes
Design – Signalized

- Signalized Turbo Roundabouts
- High volumes
- Diameter 360 ft
Traffic Flows
## Traffic flow

### Capacity of intersection alternatives

<table>
<thead>
<tr>
<th>Kruispuntvorm</th>
<th>Praktisch</th>
<th>Theoretisch</th>
<th>Enterend en conflictvolvolumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enkelstrookroonde</td>
<td>2.000</td>
<td>2.700</td>
<td>1.100 - 1.500</td>
</tr>
<tr>
<td>Twee strookroonde met eenstrookstoeritten en afritten</td>
<td>2.200</td>
<td>3.600</td>
<td>1.500 - 1.800</td>
</tr>
<tr>
<td>Twee strookroonde met twee strookstoeritten en eenstrook-afritten</td>
<td>3.000</td>
<td>3.600</td>
<td>1.800 - 2.000</td>
</tr>
<tr>
<td>Twee strookroonde met twee strookstoeritten en -afritten</td>
<td>3.500</td>
<td>4.000</td>
<td>2.100 - 2.400</td>
</tr>
<tr>
<td>Turboronde basisvorm (zie figuur 12)</td>
<td>3.500</td>
<td>3.800</td>
<td>1.900 - 2.100</td>
</tr>
<tr>
<td>Spiraalroonde (zie figuur 12)</td>
<td>4.000</td>
<td>4.300</td>
<td>2.000 - 2.300</td>
</tr>
<tr>
<td>Rotorroonde (driestroomstoeritten, twee strook-afritten, zie figuur 12)</td>
<td>4.500</td>
<td>5.000</td>
<td>2.500 - 2.800</td>
</tr>
<tr>
<td>Turboverkeersplein (per toevoer 3 × 2 rijstroken, zie hoofdstuk 7)</td>
<td>8.500</td>
<td>11.000</td>
<td>4.200</td>
</tr>
<tr>
<td>Voorrangskruispunt (met eventueel linksafvallen)</td>
<td>1.500</td>
<td>1.800</td>
<td>1.100</td>
</tr>
<tr>
<td>Viertasch kruispunt met VRI (per toevoer 3 × 1 rijstroom)</td>
<td>3.500</td>
<td>4.000</td>
<td>3.800</td>
</tr>
<tr>
<td>Viertasch kruispunt met VRI (per toevoer 3 × 2 rijstroken)</td>
<td>7.500</td>
<td>8.000</td>
<td>3.800</td>
</tr>
</tbody>
</table>

© CROW Guideline: turboroodes
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 of 4 legs, geometry
• Output: saturation rate (max 80%), average waiting time (max 50 seconds)

Tool determines the appropriate (turbo) roundabout type
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
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’)

[Images of WB-62 and WB-40 trucks through a roundabout]
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

Upstream

verhoogde rijbaanscheiding

Safe to ride over

Verhoogde rijbaanscheiding

= Elevated Lane Separation

High contrast

Center island
 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?

Vragen en discussie

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