Capacity in the Netherlands

Empirical features

Henk Taale
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Video ramp metering
## Impact ramp metering on capacity

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity motorway</th>
<th>Speed motorway</th>
</tr>
</thead>
<tbody>
<tr>
<td>A10 Coentunnel (1st system in NL)</td>
<td>=</td>
<td>+20 km/hr</td>
</tr>
<tr>
<td>A10 Coentunnel (4 on-ramps)</td>
<td>+2%</td>
<td>+20 km/hr</td>
</tr>
<tr>
<td>A13 Delft-Zuid (1st evaluation)</td>
<td>+5%</td>
<td>Not measured</td>
</tr>
<tr>
<td>A13 Delft-Zuid (2nd evaluation)</td>
<td>+4%</td>
<td>Not measured</td>
</tr>
<tr>
<td>A12 Zoetermeer</td>
<td>+3%</td>
<td>+3 km/hr</td>
</tr>
<tr>
<td>A20 Schiedam-Noord</td>
<td>&gt;</td>
<td>+6 km/hr</td>
</tr>
<tr>
<td>A29 Barendrecht</td>
<td>+5%</td>
<td>+3 km/hr</td>
</tr>
<tr>
<td>A8 Kolkweg</td>
<td>=</td>
<td>+2 km/hr</td>
</tr>
<tr>
<td>A2 Vianen</td>
<td>+5%</td>
<td>+5 km/hr</td>
</tr>
<tr>
<td>A2 Boxtel</td>
<td>=</td>
<td>Not measured</td>
</tr>
<tr>
<td>A2 Vinkeveen</td>
<td>+2%</td>
<td>+10 km/hr</td>
</tr>
</tbody>
</table>
What is capacity?
What is capacity?

• Dutch definition for motorways
  The maximum number of vehicles per unit of time that can reasonably pass a cross-section or section of the road during a certain period of time under current road, traffic and traffic management conditions

• Aspects
  – Reasonably: stochastic variable
  – Certain period of time: aggregation influences outcome
  – Current conditions: road design, weather conditions, trucks, measures
  – Capacity drop
Capacity drop

The diagram illustrates the relationship between flow and density. As the density increases, the capacity drop decreases.
Estimating capacity

• Rules of thumb
• Simulation
  – FOSIM (Freeway Operations SIMulation)
• Data analysis
  – Free flow capacity: Product-Limit method of Brilon
  – Queue discharge capacity: empirical distribution function
FOSIM

- Input geometry and traffic
- Run simulations with different random seeds
- Microscopic model based on theory of Wiedemann (1974)
- Determine distribution and capacity value
Product-Limit method Brilon

- No empirical distribution assumed
- One observation per congestion period

\[ F_c(q) = 1 - \prod_{i: q_i < q} \frac{k_i - d_i}{k_i}, \quad i \in \{B\} \]

- Where to measure?
- Which criterion for congestion?
- Aggregation of data
Empirical Distribution Function

- Congestion (speed) upstream
- Flow downstream
- Congestion criterion: 70 km/h
- Distribution
- Median is capacity value
Trucks

- PCU value dependent on traffic situation
- Relation between capacity and % truck
- Value of 2.1
Traffic management and capacity

<table>
<thead>
<tr>
<th>Measure</th>
<th>Capacity</th>
<th>Delay</th>
<th># Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queue tail warning</td>
<td>+2%</td>
<td></td>
<td>-19%</td>
</tr>
<tr>
<td>Dynamic speed limits</td>
<td>[-9%, +5%]</td>
<td>[-24%, +36%]</td>
<td></td>
</tr>
<tr>
<td>Ramp metering</td>
<td>+2%</td>
<td>-11%</td>
<td></td>
</tr>
<tr>
<td>Hard shoulder running</td>
<td>+20%</td>
<td>-42%</td>
<td>[-85%, -25%]</td>
</tr>
</tbody>
</table>

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Dutch Highway Capacity Manual

- Research on LOS since 1968
- First Dutch HCM in 1999 (CIA)
- Fourth version published in 2015
- Based on extensive measurements and simulations
- Capacity determined on 75 locations using data
  - Average 15% lower queue discharge capacity
  - Range between 0% and 30% lower
- Values for ‘standard’ conditions
What is standard?

• A maximum speed limit of 100 or 120/130 km/h
• 15% truck traffic
• Design according to Dutch guidelines for freeways
• No large objects near the road side (e.g. noise barriers)
• No distractions caused by objects or events near the road
• No steep gradients (< 2.5%) or less steep over longer distance
• Day light and with dry weather
• Good quality road surface
• MTM equipped, but no other active traffic management measures
## Standard capacity values

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lane (&gt; 1500 m)</td>
<td>1,900</td>
<td>1,900</td>
<td>1,900</td>
<td>1,900</td>
</tr>
<tr>
<td>1 lane (&lt;1500 m)</td>
<td>2,100</td>
<td>2,100</td>
<td>2,100</td>
<td>2,100</td>
</tr>
<tr>
<td>2 lanes</td>
<td>4,300</td>
<td>4,300</td>
<td>4,200</td>
<td>4,300</td>
</tr>
<tr>
<td>3 lanes</td>
<td>6,700</td>
<td>6,700</td>
<td>6,300</td>
<td>6,200</td>
</tr>
<tr>
<td>4 lanes</td>
<td>9,000</td>
<td>9,000</td>
<td>8,200</td>
<td>8,200</td>
</tr>
<tr>
<td>5 lanes</td>
<td>11,300</td>
<td>11,300</td>
<td>10,000</td>
<td>10,250</td>
</tr>
<tr>
<td>6 lanes</td>
<td>13,400</td>
<td>13,400</td>
<td>11,500</td>
<td>12,000</td>
</tr>
<tr>
<td>7 lanes</td>
<td></td>
<td></td>
<td></td>
<td>13,500</td>
</tr>
</tbody>
</table>
Weaving and capacity

The influence of weaving traffic on the capacity
(2+2 symmetrical weaving section)

- Less truck traffic
- More truck traffic
- Standard
- Longer weaving section

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Deviant conditions

- Rain: light and moderate 0.95, heavy 0.90
- Light: at night with lighting 0.97, without lighting 0.95
- Road works

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Width</th>
<th>Speed</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1 system</td>
<td>L 3,00; R 3,25</td>
<td>90 km/hr, 90 km/hr</td>
<td>3,400 veh/hr, 3,000 veh/hr</td>
</tr>
<tr>
<td>4-0 system</td>
<td>L 1,95; R 2,85</td>
<td>70 km/hr, 70 km/hr</td>
<td>2,600 veh/hr, 2,800 veh/hr</td>
</tr>
<tr>
<td></td>
<td>L 2,35; R 2,85</td>
<td>70 km/hr, 70 km/hr</td>
<td>2,800 veh/hr, 3,000 veh/hr</td>
</tr>
<tr>
<td></td>
<td>L 2,50; R 3,00</td>
<td>70 km/hr, 90 km/hr</td>
<td>3,000 veh/hr, 3,400 veh/hr</td>
</tr>
<tr>
<td></td>
<td>L 3,00; R 3,25</td>
<td>90 km/hr, 90 km/hr</td>
<td>3,400 veh/hr, 3,400 veh/hr</td>
</tr>
</tbody>
</table>
Applications of capacity

• Planning
  – Analysis of future bottlenecks
  – Design

• Modelling
  – Transport models
  – Traffic models

• Operations
  – Planning of road works
  – Detours
  – Traffic state prediction (incidents)
What about capacity in cities?

- Intersection type
  - Signalised
  - Roundabout
  - Give way
- Intersection aspects
  - Signal control plan
  - Distance between intersections
- Vehicles or travellers?
Contact

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