Motorway Weaving Sections (study completed in 2013)
**Main purpose:**
To analyse the capacity of weaving sections in DK

- Collect existing knowledge, HCM 2010
- Literature review
- Locate weaving sections in DK
- Find method for traffic data collection
- Collect data
- Analysis
- Model development
Type A

- A
- B
- C
- D

Total: 4
Length: 280 – 330 m

Type B

- A
- B
- C
- D

Total: 14
Length: 100 – 125 m
Data collection by use of video (3-4h recording)

Vehicle by vehicle data !!

Data aggregated to 1, 2, 5 and 10 min intervals
Type B - 2 min data

Speed - Density

Speed - Flow

Flow - Density

Type B
Type B

0 % weaving
Capacity: 4200 pc/h

100 % weaving
Capacity: 1000 - 1500 pc/h

10-90 % weaving
Capacity: 1200 - 4000 pc/h
Simple approach:
1 weaving pc = non weaving pc x Fve
Weaving vehicles have greater impact on weaving section speed than non-weaving vehicles

Factor 1.3 – 1.8

<table>
<thead>
<tr>
<th>Weaving flow (V_{ad} + V_{bc}) (pc/1min)</th>
<th>Non weaving flow (V_{ac} + V_{bd}) (pc/1min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10</td>
<td>71 70 68 66 67 65</td>
</tr>
<tr>
<td>10-15</td>
<td>70 68 66 65 63 62</td>
</tr>
<tr>
<td>15-20</td>
<td>68 66 65 63 62 60</td>
</tr>
<tr>
<td>20-25</td>
<td>66 64 63 61 59 58</td>
</tr>
</tbody>
</table>

Table: Speed of weaving section at different weaving / non-weaving flow rates
Simpel Model

Fve: Flow modification factor for weaving flow

Depends on:
- Length of weaving section
- Volume of crossing/merging flow

![Graph showing Fve vs. Volume of conflict flow (pc/h) for different lengths (100m, 250m, 500m, 750m, 1000m, 1250m)]
Simpel Model
Type B

A  Max 2100 pc/h

V_{AD} \cdot F_{ve} + V_{BC} \cdot F_{ve} < 2100 pc/h

B  Max 2100 pc/h

V_{BC} \cdot F_{ve} + V_{AC} < 2100 pc/h

C

D

V_{AC} \cdot F_{ve} + V_{BD} < 2100 pc/h
Max flow at different % weaving
(same % from A and B)

Flow from A (pc/h)

Flow from B (pc/h)

Share of weaving (%)

- 0%
- 10%
- 25%
- 40%
- 50%
- 60%
- 75%
- 100%

Rural Road Design Meeting – 3- 4 April 2014 - Copenhagen
Type B

Model implemented in spreadsheet

Input:
- Flow AC, AD, BC, BD
- Length

Output:
- V/C ratio

Belastning (d/c)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0,60</td>
<td>0,45</td>
<td>0,79</td>
<td>0,26</td>
</tr>
<tr>
<td>AD + BC Kryds</td>
<td>0,69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC + BC - Flet</td>
<td>0,97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BD + AD - Flet</td>
<td>0,33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samlet</td>
<td>0,65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Length = 120m
Type A

A

C

B

D

A1

A2

B

C1

C2

D

Rural Road Design Meeting – 3- 4 April 2014 - Copenhagen
Type A

Model implemented in spreadsheet

Input:
- Flow AC, AD, BC, BD
- Length
- Share of AC in left lane

Output:

V/C ratio

Belastning (d/c)

<table>
<thead>
<tr>
<th></th>
<th>A2C2</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>AD + BC Kryds</th>
<th>AC + BC - Flet</th>
<th>BD + AD - Flet</th>
<th>Samlet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0,98</td>
<td>0,50</td>
<td>0,41</td>
<td>0,72</td>
<td>0,16</td>
<td>0,58</td>
<td>0,87</td>
<td>0,18</td>
<td>0,52</td>
</tr>
</tbody>
</table>

Length = 300m

Rural Road Design Meeting – 3- 4 April 2014 - Copenhagen
Capacity at non signalised intersections (study completed in 2010)
Capacity at non signalised intersections

- Capacity model based on gap acceptance theory (Tanners gap acceptance formula)
- Update values for critical gap and follow up times
- Driver behaviour observed by use of video recordings

Data from:

- Five rural 3-arm intersections (give way)
- One rural 4-arm intersection (stop controlled)
- Five urban 3-arm intersections (give way)
Rural areas
### 3-arm rural

<table>
<thead>
<tr>
<th>Passenger cars</th>
<th>Critical gap</th>
<th>Follow up time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right turn from minor</td>
<td>7.0 sec</td>
<td>3.3 sec</td>
</tr>
<tr>
<td>Left turn from minor</td>
<td>6.9 sec</td>
<td>3.7 sec</td>
</tr>
<tr>
<td>Left turn from major</td>
<td>5.6 sec</td>
<td>2.4 sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heavy vehicles</th>
<th>Critical gap</th>
<th>Follow up time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck/bus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right turn from minor</td>
<td>7.2 sec</td>
<td>5.4 sec</td>
</tr>
<tr>
<td>Left turn from minor</td>
<td>8.0 sec</td>
<td>5.8 sec</td>
</tr>
<tr>
<td>Left turn from major</td>
<td>7.3 sec</td>
<td>4.6 sec</td>
</tr>
<tr>
<td>Semitrailer/truck w. trailer</td>
<td>(8.7 sec)</td>
<td>(8.8 sec)</td>
</tr>
<tr>
<td>Truck/bus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right turn from minor</td>
<td>5.4 sec</td>
<td>6.7 sec</td>
</tr>
<tr>
<td>Left turn from minor</td>
<td>5.8 sec</td>
<td>8.1 sec</td>
</tr>
<tr>
<td>Left turn from major</td>
<td>4.6 sec</td>
<td>6.5 sec</td>
</tr>
<tr>
<td>Semitrailer/truck w. trailer</td>
<td>(8.8 sec)</td>
<td>(8.8 sec)</td>
</tr>
</tbody>
</table>
**PCU – values for heavy vehicles**

<table>
<thead>
<tr>
<th></th>
<th>Truck/bus</th>
<th>Semitrailer/ truck w. trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right turn from minor</td>
<td>1.4 (1.3-1.6)</td>
<td>2.2 (2.0-2.6)</td>
</tr>
<tr>
<td>Left turn from minor</td>
<td>1.7 (1.6-1.9)</td>
<td>3.1 (2.2-4.4)</td>
</tr>
<tr>
<td>Left turn from major</td>
<td>2.3 (1.8-2.8)</td>
<td>4.1 (2.6-5.8)</td>
</tr>
</tbody>
</table>
Empirical data

Left turn from minor - empirical data

- 3-arm rural
- Timegap model (T=6,9 d=3,7)
- Ekspon. (3-arm rural)

Flow on major (pc/h)

Flow on minor (pc/h)

Left turn flow from minor (pc/h)
Signalised intersections
Follow-up times and pcu-values
(study completed in 2013)
Main purpose:

To study follow-up times and PCU-values for signal-controlled intersections

Studied flows:

• Separate right/left turn (right of way)

• Straight going (left/right lane)

• Right turn and left turn
  (with give way for cyclists/pedestrians/motor vehicles)

10 signalized intersections – in total 15 traffic flows (rural / urban)
Follow-up times for passenger cars (example)
Driver behavior in streams that should give way for other road users

A

53 obs

B

408 obs

C

578 obs

109 obs

143 obs

698 obs
<table>
<thead>
<tr>
<th>Traffic stream</th>
<th>Follow-up time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right turn - right of way (&gt;4. queue pos.)</td>
<td>2.3 – 2.4 sec</td>
</tr>
<tr>
<td>Left turn – right of way (&gt;4. queue pos.)</td>
<td>1.7 – 2.0 sec</td>
</tr>
<tr>
<td>Straight ahead (&gt;4. queue pos.)</td>
<td>1.6 – 2.0 sec</td>
</tr>
<tr>
<td>Right turn – give way</td>
<td>2.6 – 3.0 sec</td>
</tr>
<tr>
<td>Left turn – give way</td>
<td>2.1 – 2.2 sec</td>
</tr>
</tbody>
</table>
## PCU-values

### Based on follow-up times

<table>
<thead>
<tr>
<th>Traffic stream</th>
<th>PCU-value</th>
<th>PCU-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Truck/bus</td>
<td>Road trains / semi-trailers</td>
</tr>
<tr>
<td>Right turn - right of way</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td>Left turn – right of way</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Straight ahead</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Right turn – give way</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>Left turn – give way</td>
<td>1.7</td>
<td>(2.2)</td>
</tr>
<tr>
<td><strong>In average – approx.</strong></td>
<td><strong>1.5</strong></td>
<td><strong>2.0</strong></td>
</tr>
</tbody>
</table>