NORDIC VEHICLE CONFIGURATION FROM VIEWPOINT OF FUEL AND TRANSPORT ECONOMY, EMISSION REDUCTION AND ROAD WEAR IMPACT

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VEHICLE DIMENSIONS IN EUROPE

Finland: Truck + trailer  Max. length 25.25 m
       Truck + semi-trailer  Max. length 16.5 m
Sweden: Max. combination length 24 m, modules 25.25 m
Norway: Truck + trailer Max. length 19 m, timber transportation
       22 m, module on restricted roads 25.25 m
Denmark: Truck + trailer Max. length 18.75 m, module on
         restricted roads 25.25 m
Netherlands: Truck + trailer Max. length 18.75 m, module on
              restricted roads 25.25 m

Other Europe: Truck + trailer Max. length 18.75 m
VEHICLE MASSES IN EUROPE

Finland: Truck + trailer  Max. combination mass 60 t
        Truck + semi-trailer  Max. combination mass 48 t

Sweden: Max. combination mass 60 t

Norway: Truck + trailer Max. combination mass 50 t,
        module on restricted roads 60 t

Denmark: Truck + trailer Max. combination mass 48 t,
        module on restricted roads 60 t

Netherlands: Truck + trailer Max. combination mass 50 t,
        module on restricted roads 60 t

Other Europe: Max. 40 t in special cases 44 t with 6 axles
DEPENCE OF GROSS MASS ON AXLES

Road trains (truck + trailer)

<table>
<thead>
<tr>
<th>Number of axles</th>
<th>Max. combination mass [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>53</td>
</tr>
<tr>
<td>7 or more</td>
<td>60</td>
</tr>
</tbody>
</table>

Articulated vehicles (truck + semi-trailer)

<table>
<thead>
<tr>
<th>Number of axles</th>
<th>Max. combination mass [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>42</td>
</tr>
<tr>
<td>6 or more</td>
<td>48</td>
</tr>
</tbody>
</table>
# MAXIMUM AXLE MASSES

Max. mass [t]

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Mass [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single axle:</td>
<td>- drive axle</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>- other</td>
<td>10</td>
</tr>
<tr>
<td>Tandem axle:</td>
<td>- air or harmonic suspension</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>- other</td>
<td>18</td>
</tr>
<tr>
<td>Triple axle:</td>
<td>- common</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>- Netherlands, air suspension</td>
<td>27</td>
</tr>
</tbody>
</table>
TARGET OF NORDIC VEHICLE CONFIGURATION

- Energy saving
- Reduction of emissions (CO2, particles, noise etc.)
- Reduction of transportation costs
- Reduction of road wear
- Reduction number of vehicles on the road for safety, traffic flow, comfort
REDUCTION OF ENERGY, EMISSIONS AND TRANSPORTATION COSTS

- Increase of vehicle mass → increase values per traffic product unit (vehicle km)

- But due to the increased payload values per transport product unit (ton km) is less
## CASES TO BE STUDIED (1)

<table>
<thead>
<tr>
<th>No.</th>
<th>Configuration</th>
<th>Number of axles</th>
<th>Gross mass</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Truck + semi-trailer</td>
<td>2 3 5</td>
<td>40</td>
<td>25.7</td>
</tr>
<tr>
<td>1</td>
<td>Truck + trailer</td>
<td>3 3 6</td>
<td>53</td>
<td>35.5</td>
</tr>
<tr>
<td>2</td>
<td>Truck + trailer</td>
<td>3 4 7</td>
<td>60</td>
<td>41.2</td>
</tr>
<tr>
<td>3</td>
<td>Truck + trailer</td>
<td>3 5 8</td>
<td>68</td>
<td>47.7</td>
</tr>
<tr>
<td>4</td>
<td>Truck + trailer</td>
<td>4 5 9</td>
<td>74</td>
<td>52.4</td>
</tr>
<tr>
<td>5</td>
<td>Truck + trailer</td>
<td>5 5 10</td>
<td>80</td>
<td>58.0</td>
</tr>
</tbody>
</table>
### Optional engines

<table>
<thead>
<tr>
<th>Engine #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore [mm]</td>
<td>127</td>
<td>127</td>
<td>127</td>
<td>127</td>
</tr>
<tr>
<td>Stroke [mm]</td>
<td>154</td>
<td>154</td>
<td>154</td>
<td>154</td>
</tr>
<tr>
<td>Number of cylinders</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Rated power/ rated engine speed [kW]/[rpm]</td>
<td>309/1900</td>
<td>345/1900</td>
<td>412/1900</td>
<td>460/1900</td>
</tr>
<tr>
<td>Maximum torque engine speed [Nm]/[rpm]</td>
<td>2100/1300</td>
<td>2160/1200</td>
<td>2800/1300</td>
<td>2880/1200</td>
</tr>
</tbody>
</table>

- 3 routes: 170 km typical Finnish, 176 km being flat and 51 km having hilly geometry
CARES TO BE STUDIED (3)

Driving technique in simulation:
Target speed
- 80 km/h legal max. speed
- 90 km/h speed limiter setting
- swinging +10 km/h on downward slopes by gravitation

Gear shift strategy
- engine speed range 1000 – 1600 rpm
- gear skipping down 2 (whole gear) up 1 (splitter used)
RESULTS: FUEL CONSUMPTION

vehicle km
RESULTS: FUEL CONSUMPTION

FUEL CONSUMPTION VS. VEHICLE GROSS MASS
Target speed 80 km/h

FUEL CONSUMPTION \([1/100 \, \text{tkm}]\)

- 460 kW
- 389 kW
- 450 kW
- 469 kW

VEHICLE MASS [kg]
VEHICLE OPERATION COSTS

VARIABLE COSTS
  fuel costs
  lubricant costs
  repair & maintenance costs
  tire costs

FIXED COSTS
  capital costs: depreciation and interest
  wages + overhead costs
  insurance costs
  vehicle tax (drive power tax)
  administrative costs
REDUCTION OF ROAD WEAR

AASHO Road Tests in USA in early 1960’s were continued later all over the world

Relationship between road wear and equivalent single axle loads (ESAL number)

Axle/bogie mass conversion to ESAL

Load distribution on more axles

Less vehicles for total load
CONCLUSIONS 1

- Simulation is an effective tool for analyzing impacts of characteristics of different vehicle configurations

- Nordic Vehicle Configuration is in many aspects superior to the Central European Configuration

- Central European articulated vehicle wear approximately 64% more road pavement per transport product unit [tkm] than Nordic road train
CONCLUSIONS 2

- Transportation in general by Central European vehicle is approximately 33% more expensive per transport product unit [ton km] than by Nordic vehicle.

- Central European articulated vehicle consumes approximately 32% more fuel per transport product unit [ton km] than Nordic road train (CO2).

- Central European articulated vehicle generates approximately 41% more nitrogen oxides per transport product unit [tkm] than Nordic road train.