Fran-Scan
Hi-Cube Intermodal Corridor
(G2, P/C 450)

Hans E. Boysen
Department of Transport Science
Royal Institute of Technology

2012-10-03
Purpose

- To identify opportunities, challenges and logistic effects of operating higher railway loading gauges in Europe
Presentation Outline

PART 1: INTERMODAL COORDINATION

PART 2: WAGONLOAD COORDINATION

PART 3: WAGONLOAD DEVELOPMENT

PART 4: SUMMARY
Cross-border intermodal transportation is growing rapidly.

Data: TA
Standard and Hi-Cube Intermodal Loads

Victoria Skeidsvoll
Highway Vehicle Height Limits

- Vision: P/C 450 rail corridor
- 4.1 m
- 4.0 m
- >4.5 m
- 4.2 m
- >4.5 m
- 4.65 m
- >4.95 m
Fran-Scan
Hi-Cube
Intermodal Corridor
(P/C 450)
Intermodal Gauge P/C 450

- Trailer width: 260 cm
- Trailer height: 450 cm
- Total height: 483 cm ATOR
- Wagon pocket height: 33 cm ATOR (UIC 571-4)

- Container/swap body width: 260 cm
- Container/swap body height: 365.5 cm
- Wagon floor height: 117.5 cm ATOR (UIC 571-4)

- ATOR = above top of rail

P = pocket
C = container
Sample Intermodal Pocket Wagons

270 mm pocket height, Sdggmrs

270 mm pocket height, Sdggmrss
Sample Intermodal Flat Wagons

820 mm floor height, Sffggmrrss (FKA)  1155 mm frame height, Sgnss
## Intermodal Load Heights in P/C 450

<table>
<thead>
<tr>
<th>Wagon floor height</th>
<th>Wagon type, examples</th>
<th>Max. container/swap body height within P/C 450</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.175 m</td>
<td>UIC 571-4</td>
<td>3.655 m</td>
</tr>
<tr>
<td>1.170 m</td>
<td>Sdgms</td>
<td>3.660 m</td>
</tr>
<tr>
<td>1.155 m</td>
<td>Sdggmrss, Sdgmrns, Sgnss</td>
<td>3.675 m</td>
</tr>
<tr>
<td>1.150 m</td>
<td>Sdggmrss-t</td>
<td>3.680 m</td>
</tr>
<tr>
<td>0.825 m</td>
<td>Sffgangmrss</td>
<td>4.005 m</td>
</tr>
<tr>
<td>0.820 m</td>
<td>Sffgangmrss (FKA)</td>
<td>4.010 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wagon pocket height</th>
<th>Wagon type, examples</th>
<th>Max. semitrailer height within P/C 450</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.330 m</td>
<td>UIC 571-4</td>
<td>4.500 m</td>
</tr>
<tr>
<td>0.310 m</td>
<td>Sdgms</td>
<td>4.520 m</td>
</tr>
<tr>
<td>0.270 m</td>
<td>Sdggmrs, Sdggmrss, Sdgms</td>
<td>4.560 m</td>
</tr>
</tbody>
</table>

ATOR = above top of rail
Volume Capacity Increase

For mega trailers with floor height 1.0 m

\[ +17\% \text{ larger unit volume capacity with intermodal gauge P/C 450 than with P/C 400.} \]
Approximate Distances

- Folkestone – Malmö ≈ 1300 km

- Sweden ≈ 16 km
- Oresund ≈ 17 km
- Denmark ≈ 190 km
- Fehmarnbelt ≈ 20 km
- Germany ≈ 480 km
- Netherlands ≈ 270 km
- Belgium ≈ 150 km
- France ≈ 110 km
- Eurotunnel ≈ 50 km
<table>
<thead>
<tr>
<th>Country</th>
<th>Corridor</th>
<th>Loading Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurotunnel</td>
<td>GB1</td>
<td>P/C 385</td>
</tr>
<tr>
<td>Øresund</td>
<td>GB-M6</td>
<td>P/C 400</td>
</tr>
<tr>
<td>Belguim</td>
<td>G2</td>
<td>P/C 410</td>
</tr>
<tr>
<td>France</td>
<td>A, C</td>
<td>P/C 450</td>
</tr>
<tr>
<td>Denmark</td>
<td>G2</td>
<td>P/C 410</td>
</tr>
<tr>
<td>Germany</td>
<td>P/C 405</td>
<td>P/C 400</td>
</tr>
<tr>
<td>Netherlands</td>
<td>P/C 422</td>
<td>P/C 410</td>
</tr>
<tr>
<td>Sweden</td>
<td>A, C</td>
<td>P/C 450</td>
</tr>
</tbody>
</table>
# Loading Gauges

<table>
<thead>
<tr>
<th>Corridor segment</th>
<th>Loading gauge, height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>M, 4.595 m</td>
</tr>
<tr>
<td>Sweden</td>
<td>SE-C, 4.83 m</td>
</tr>
<tr>
<td></td>
<td>SE-A, 4.65 m</td>
</tr>
<tr>
<td>Øresund bridge</td>
<td>P/C 450, 4.83 m</td>
</tr>
<tr>
<td>Denmark</td>
<td>G2, 4.65 m</td>
</tr>
<tr>
<td>Fehmarnbelt link</td>
<td>SE-C, 4.83 m</td>
</tr>
<tr>
<td>Germany</td>
<td>G2, 4.65 m</td>
</tr>
<tr>
<td>Netherlands</td>
<td>G2, 4.65 m</td>
</tr>
<tr>
<td>Betuwe line</td>
<td>GC, 4.65 m</td>
</tr>
<tr>
<td>Belgium</td>
<td>GB-M6, 4.602 m</td>
</tr>
<tr>
<td>France</td>
<td>GB1, 4.32 m</td>
</tr>
<tr>
<td>Eurotunnel</td>
<td>5.75 m</td>
</tr>
</tbody>
</table>

Sufficient height of loading gauge SE-C and Eurotunnel for P/C 450
Vertical Clearance Requirements to OHL

- Overhead line construction tolerance: 30 mm
- Contact wire dynamic movement: 50 mm
- Electrical minimum clearance (EBO, VDE 0115-1):
  - 25 kV 220 mm
  - 15 kV 150 mm
  - 3 kV 50 mm
  - 1.5 kV 35 mm
- Vehicle dynamic movement (TSI WAG): 50 mm
- Track ballast tamping allowance: 50 mm

⇒ Total clearance 215 mm to 400 mm needed to OHL.
Loading Gauges and OHL Heights

<table>
<thead>
<tr>
<th>Corridor segment</th>
<th>Loading gauge, height</th>
<th>OHL voltage</th>
<th>Total clearance needed</th>
<th>OHL height needed for P/C 450</th>
<th>OHL normal height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>M, 4.595 m</td>
<td>15 kV</td>
<td>0.33 m</td>
<td>5.16 m</td>
<td>5.5 m</td>
</tr>
<tr>
<td>Sweden</td>
<td>SE-C, 4.83 m</td>
<td>15 kV</td>
<td>0.33 m</td>
<td>5.16 m</td>
<td>5.5 m</td>
</tr>
<tr>
<td></td>
<td>SE-A, 4.65 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Øresund bridge</td>
<td>P/C 450, 4.83 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.23 m</td>
<td>5.33 m</td>
</tr>
<tr>
<td>Denmark</td>
<td>G2, 4.65 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.23 m</td>
<td>5.3 m, 5.5 m</td>
</tr>
<tr>
<td>Fehmarnbelt link</td>
<td>SE-C, 4.83 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.23 m</td>
<td>5.3 m</td>
</tr>
<tr>
<td>Germany</td>
<td>G2, 4.65 m</td>
<td>15 kV</td>
<td>0.33 m</td>
<td>5.16 m</td>
<td>5.3 m, 5.5 m</td>
</tr>
<tr>
<td>Netherlands</td>
<td>G2, 4.65 m</td>
<td>1.5 kV</td>
<td>0.215 m</td>
<td>5.045 m</td>
<td>5.5 m</td>
</tr>
<tr>
<td>Betuwe line</td>
<td>GC, 4.65 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.23 m</td>
<td>5.5 m</td>
</tr>
<tr>
<td>Belgium</td>
<td>GB-M6, 4.602 m</td>
<td>3 kV</td>
<td>0.23 m</td>
<td>5.06 m</td>
<td>5.3 m</td>
</tr>
<tr>
<td>France (north)</td>
<td>GB1, 4.32 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.23 m</td>
<td>5.5 m</td>
</tr>
<tr>
<td>Eurotunnel</td>
<td>5.75 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.23 m</td>
<td>6.3 m</td>
</tr>
</tbody>
</table>

* Sufficient clearances to normal OHL heights for P/C 450.
Lift-on Lift-off Loading

- Lift-on lift-off requires load unit reinforcements.
- Few semitrailers are reinforced (<10 %).
Roll-on Roll-off Wagons in P/C 450

Wheels > ø0.63 m
Other Loads: Construction Equipment

1268 mm floor height, Rs
Other Loads: House Sections and Lumber

Bengt Dahlberg

Peter Norberg

1268 mm floor height, Rs

1235 mm floor height, Rns
House Sections and Lumber in P/C 450

:: Lumber can be stacked 1 package higher (+50%) in intermodal gauge P/C 450 than in P/C 400.
Lumber: Three Packages High (+50 %)

1305 mm riser height, Sgns
Swedish Softwood Lumber Export to the Main European Markets

Million cubic meters

Statistics Sweden, Swedish Forest Industries Federation
Presentation Outline

PART 1: INTERMODAL COORDINATION

PART 2: WAGONLOAD COORDINATION

PART 3: WAGONLOAD DEVELOPMENT

PART 4: SUMMARY
Railway Loading Gauges

Vision: G2 rail corridor
Loading Gauge G2

- Central and eastern Europe use the G2 gauge.
- HS1 and Eurotunnel are cleared for the G2 gauge.

- How to connect?

![Map showing the connection between London and Calais via Folkestone and Ramsgate](image-url)
Clearing a Path for G2 to Britain

- Belgium: GB-M6 and P/C 450 nearly envelop G2.

- France: GB1 and P/C 450 nearly envelop G2.

:. Minor additional gauge enlargement would open London, Folkestone, northern France and Belgium to the larger wagons of central and eastern Europe.
Sample Enclosed Wagons

G1 gauge, Habbiins 14 wagon
IL 22.6 m, IW 2.83 m, V 173 m³

G2 gauge, Habbiins 11 wagon
IL 21.838 m, IW 2.83 m, V 186.3 m³

Note: V denotes total volume capacity.
Volume Capacity Increase

- Volume capacity comparison of Habbiins 14 (G1) and Habois 11 (G2), per meter of inside length.

\[ \therefore +11\% \text{ larger wagon volume capacity with loading gauge G2 than with G1.} \]
Presentation Outline

PART 1: INTERMODAL COORDINATION

PART 2: WAGONLOAD COORDINATION

PART 3: WAGONLOAD DEVELOPMENT

PART 4: SUMMARY
Maximising Loading Gauge Height

<table>
<thead>
<tr>
<th>Corridor segment</th>
<th>OHL normal height</th>
<th>OHL voltage</th>
<th>Total clearance needed</th>
<th>Loading gauge height possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>5.5 m</td>
<td>15 kV</td>
<td>0.33 m</td>
<td>5.17 m</td>
</tr>
<tr>
<td>Sweden</td>
<td>5.5 m</td>
<td>15 kV</td>
<td>0.33 m</td>
<td>5.17 m</td>
</tr>
<tr>
<td>Øresund bridge</td>
<td>5.33 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>4.93 m</td>
</tr>
<tr>
<td>Denmark</td>
<td>5.3 m, 5.5 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>4.90 m</td>
</tr>
<tr>
<td>Fehmarnbelt link</td>
<td>5.3 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>4.90 m</td>
</tr>
<tr>
<td>Germany</td>
<td>5.3 m, 5.5 m</td>
<td>15 kV</td>
<td>0.33 m</td>
<td>4.97 m</td>
</tr>
<tr>
<td>Netherlands</td>
<td>5.5 m</td>
<td>1.5 kV</td>
<td>0.215 m</td>
<td>5.285 m</td>
</tr>
<tr>
<td>Betuwe line</td>
<td>5.5 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.10 m</td>
</tr>
<tr>
<td>Belgium</td>
<td>5.3 m</td>
<td>3 kV</td>
<td>0.23 m</td>
<td>5.07 m</td>
</tr>
<tr>
<td>France (north)</td>
<td>5.5 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.10 m</td>
</tr>
<tr>
<td>Eurotunnel</td>
<td>6.3 m</td>
<td>25 kV</td>
<td>0.40 m</td>
<td>5.90 m</td>
</tr>
</tbody>
</table>

*: Loading gauge height 4.90 m possible under normal OHL height.*
**Desired Flat-Top Loading Gauges**

- **OHL 5.30 m ATOR**
- **Clearance ≥ 0.40 m (25 kV)**
- **SE-C**  
  3.60 m × 4.83 m
- **Medium**  
  3.40 m × 4.83 m
- **Narrow**  
  3.15 m × 4.83 m
- **P/C 450**  
  2.60 m × 4.83 m
- **P/C 400**  
  2.60 m × 4.33 m
- **Pocket 0.33 m ATOR**  
  TOR 0.00 m
Loading Gauge Comparison

Loading gauge useful cross section (m²)

Note: Largest inscribed rectangle above floor height, 1.2 m.
Opportunities of a Larger Gauge

133 m³ volume, Hiqqrrs-vw wagon

158 m³ volume, SECU container
Opportunities of a Larger Gauge

Frederik Tellerup

Michael Nilsson

5 seats across, X53 unit

3.45 m width, X55 unit

KTH Railway Group • Center for research and education in railway technology
Haimnss

:: 152 m$^3$ rectangular volume in ≈15.2 m length, gauge 315×483.
For Paper and Lumber Export

Habinss

.: 200 m³ rectangular volume in ≈19.6 m length, gauge 315×483.
For Paper and Lumber Export

Sinss

3.56 m (140”) paper rolls can be carried by rail, gauge 315×483.
Presentation Outline

PART 1: INTERMODAL COORDINATION

PART 2: WAGONLOAD COORDINATION

PART 3: WAGONLOAD DEVELOPMENT

PART 4: SUMMARY
Conclusions

- P/C 450 intermodal gauge (2.6 m×4.83 m) enables:
  - 4.50 m high semitrailers, loaded by lift-on lift-off
  - 4.00 m high semitrailers, loaded by roll-on roll-off
  - 1.15 m high lumber packages, loaded three tall.

- P/C 450 fits within the Swedish C loading gauge.

- Overhead line normal heights are sufficient for P/C 450 Norway – France – Eurotunnel – Folkestone.

- Minor expansion would enable G2 gauge to London.

- 3.15 m×4.83 m flat-top enables 3.56 m paper rolls.
Next

- Survey clearances on Fran-Scan connecting lines:
  - Vännäs – Boden
  - Luleå – Narvik
Recommendations

• Show the applicable P/C intermodal gauges in all railway network statements: JBV✓, ØSB✓, DB✓

• Implement P/C 450 initially on Fran-Scan connecting lines:
  - Esbjerg – København 2015
  - Trelleborg – Malmö 2015
  - Hallsberg – Mjölby
  - Alnabru – Skålebol, Drammen – Kil

• Implement in the Fran-Scan corridor:
  - P/C 450: København – Hamburg – Lille – Calais
  - G2: Rosendaal – Lille – Calais
Thank you!