Challenges and Lessons in High Speed Railway Planning in Denmark

International Workshop on High-Speed Rail Planning and Operations 2015, Washington DC
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Technical University of Denmark
Danish Strategic Rail Plan

• U.S. $1.5 Billion*
  – Copenhagen-Ringsted
  – Nearly complete, official opening 2018

• U.S. $5 Billion
  – High Speed Alignment for Fyn & Jylland
  – European Signal Standard
  – Electrification

• U.S. $6.9 Billion
  – Femern Bælt-forbindelsen
    Femern Belt Link
  – Copenhagen-Rødby-Hamburg
  – Ferry replacement

*10.3, 28.5 and 41 Bil. DKK respectively
New Signals

- ERTMS level 2
- Entirely cab signalled
- No wayside signals
- CBTC for Copenhagen suburban trains
Electrification

25k v, 50Hz

(15k v, 16.3Hz, Sweden & Germany)
Femern Bælt Forbindelsen
Strategic High Speed Rail Planning in Denmark

• The Danish Network Today
• Significant High Speed Projects
• Focus on the Whole Journey
• The Planning Process
• Future Forecast
A Familiar Scenario

- Network Originates from 1850-1880
- Primarily to Connect Port Cities
- Largely Unchanged Since 1940
The Danish Network

Danish Public Transit

Togafgange
- 2 - 50
- 51 - 100
- 101 - 250
- 251 - 500
- 501 - 1,480

Busafgange
- 1 - 100
- 101 - 200
- 201 - 500
- 501 - 1,000
- 1,001 - 2,385

Aarhus

The Danish Network

0 5 km

DTU Transport, Technical University of Denmark
The Hour Model

Travel Times Today:
Copenhagen-Odense, 75 min.
Copenhagen-Aarhus, 170 min.
Copenhagen-Aalborg, 259 min.

Percent Reduction Required:
Copenhagen-Odense, 20%
Odense-Aarhus, 37%
Aarhus-Aalborg, 33%

Not a uniform network upgrade
Goal is NOT fastest train route
Why One Hour?

• Trains from both directions arrive simultaneously
• Better connections to other services
• Similar to airline hub scheduling
• Less waiting time to/from bus, local rail
Jutland Main Today
High Speed Projects

- 23 minutes trip reduction
- US $86 million per minute
## Incremental Time Savings

<table>
<thead>
<tr>
<th>Travel Time Odense-Aarhus</th>
<th>Diesel &gt; IC3 180 kmh</th>
<th>IC4 200 kmh</th>
<th>Electric &gt; ET 200 kmh</th>
<th>ICE 250 kmh</th>
<th>Velaro 300 kmh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fastest Scheduled 2015</td>
<td>93 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced timetable slack, 2016</td>
<td>87 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“” and non-stop trip</td>
<td>78 min</td>
<td>78 min</td>
<td>77 min</td>
<td>77 min</td>
<td>77 min</td>
</tr>
<tr>
<td>“”, “”, and high speed network</td>
<td>61 min</td>
<td><strong>58 min</strong></td>
<td>57 min</td>
<td>55 min</td>
<td>55 min</td>
</tr>
</tbody>
</table>

*IC3 >> ICE; 78-55=23
The Last Kilometer

• Often the Weak Link
• Coordination and Integration
• Large Scale Schedule Optimization
• Information for Riders
• Reliability and Robustness
  – Strong punctuality
  – Tools for response to failures
• Long Term: Grow Customers Near the System
The Whole Journey

HSR competes because local journey is efficient
Seamless Journey From Origin to Destination

- 38% of this journey time is local travel
  - 170 min. intercity train
  - 105 min. transit connection
- HSR will increase this ratio
- Customer service focus shifts to local connections
Integration, Information

• Three Modes
  – Bus
  – Suburban
  – Intercity

• Four Providers
  – Movia
  – S-tog
  – DSB
  – Midttrafik

• Updated, Current

The Whole Journey
Planning the København System

• The Players
  – DSB
  – Banedanmark
  – Movia

• Rail Sequence
  – DSB service design
  – Timetable agreement with Banedanmark

• Bus Sequence
  – Movia service design
  – Local subsidy agreement
  – Subcontract of bus routes
The Planning Process

DSB Planning Cycle

<table>
<thead>
<tr>
<th></th>
<th>2+ years</th>
<th>1 year</th>
<th>2 months</th>
<th>Now</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timetable</strong></td>
<td>Commercial aspects</td>
<td>Fixed departure and arrival minutes.</td>
<td>Track maintenance and abnormal days</td>
<td>Disturbances and delays</td>
</tr>
<tr>
<td><strong>Rolling stock</strong></td>
<td>Investments / maintenance strategy</td>
<td>&quot;Standard week&quot; capacity and rotations</td>
<td>Different capacity on calendar days</td>
<td>Dispatching rolling stock and maintenance tracking</td>
</tr>
<tr>
<td><strong>Personnel</strong></td>
<td>Hiring / training</td>
<td>Duties and anonymous rosters</td>
<td>Update duties</td>
<td>Dispatching personnel</td>
</tr>
</tbody>
</table>

*Steen Larsen, DSB*
The Planning Process

Integrated Timetable Challenges

• DSB releases timetables less than six months from start date
• Movia negotiates bus contracts a year in advance
• Buses are also bound by local funding agreements
• Can be difficult to coordinate bus and rail with current mathematical models
Future Forecast

Integrated Planning and Optimisation of Public Transport (IPTOP)
• Five Year Project: 2015-2019
• $2.73 Million
• Danish “Innovationsfonden”
• Timetable Optimization and Simulation
  – Integrated across modes
  – Integrated across resources (rolling stock, crew)
Future Forecast

Land Use Planning

Customers closer to station more likely to use rail

Future land use policy (green) to double development near stations

Population within 1 km of station
Summary

• High speed rail is not a ground based airplane
• Strategic terminal/station locations and integrated local transit necessary
• Service design must be for a complete journey
• Long term, whole network planning saves money
• The high speed train is only part of the project
Thank You