Gröna Tåget (Green Train)

The next generation of High-Speed trains for Scandinavia

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- 12.7.2012, Session: Rolling Stock 4 – Technical development
What is Gröna Tåget?

- A Swedish research and development programme aiming at
  - defining a concept for the next generation HS trains for long distance and fast regional services
  - Developing appropriate technology suitable for Northern European countries

- Involves most stakeholders in Swedish railway business

- Programme carried out 2005-2012

- Total budget ca. 17 MEUR (22 MUSD)

- Improved environmental performance
  - Energy use per pass-km should be reduced
  - No higher external noise despite increased speed

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Gröna Tåget concept

- Quite small units to run in multiple by demand (300-1000 seats)
  - **Capacity** according to need (higher load factor)
  - **Different destinations** by coupling/uncoupling (avoiding train change)

- **Wide body (~3.5 m)** → 3+2 seating → cost reduction 13% (per seat-km)

- **Short travel time (on upgraded and new infrastructure)**
  - Top speed 250 (-320) km/h
  - **Tilting carbody** is needed on old main lines: curve radii (250-600-) 1000-1600 m

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Additional requirements to European standards (TSI, EN)

- **Mixed traffic** with heavy freight trains, **frost upheaval** → **larger track defects**. Requires **track-friendly trains** (smooth ride on non-perfect track, with moderate track deterioration)

- The **modest population density**, requires **flexible trains** (4 – 12 cars). → 2 or 3 pantographs at short distance.

- High requirements for **disabled passengers** (preferably level entrances and/or lift facilities within the train)

- **High braking deceleration** (short pre-signalling distance)

- Reliable operation also under **harsh winter conditions**
The climate challenge in northern European countries

- 3-6 months average below zero
- Occasionally -40°C
- Heavy snowfall (dry, wet)

→ A lot of measures must be applied compared to a “standard” high-speed train,

Many of these measures must be considered early in the design phase
Cost reduction

According to Gröna Tåget studies:

Total operating cost per pass-km when different factors are changed by 20 % (not combined)

- Reduced travel time: -8%
- Higher load factor: -16%
- Improved space utilization: -11%
- Reduced purchase price: -6%

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Testing

Prototype and certification testing 2006 – 2008

STEP 1 2006-07
- Improved radial steered bogies (self-steering)
- Bogie noise shield

STEP 2 2007-08
- Modified radial steered bogies with Active Lateral Suspension (ALS) Permanent magnet motors
- Mechatronic bogies w Active Radial Steering (ARS)
- Bogie noise shield

Endurance & reliability testing in revenue service (2009-2011)

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Propulsion

- **Permanent Magnet (PM) Motors** are successfully tested (performance and endurance).
  - Reduced losses, **higher energy efficiency**
  - Reduced need for cooling (forced cooling via air ducts eliminated; no rotor cooling)
  - **Reduced mass** and size; improved power/mass ratio

- **Improved pantograph** for multiple operation on medium-quality catenary (tested up to 303 km/h on catenary for 200)

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Track-friendly technology

- 2005 – 2008 (-2011) particular focus on
  - **Track-friendly bogies** (passive self-steering + mechatronic)
    Track forces + running stability measured by instrumented wheels
  - **Ride quality** on non-perfect track, including active suspension
    - Simulation, hardware, certification testing, endurance testing
Further testing and studies 2006 – 2011

• Aerodynamics
• **Winter climate protection** at high-speed operation
• **Carbody tilt** systems performance & measures to reduce motion sickness.
• Noise reduction (external + internal)
• Market, economy, capacity in mixed traffic
• Travel time and energy use

Winter testing
Travel time performance

Simulated running time benefit on typical Swedish lines is about 10%. Example: Stockholm–Gothenburg, 4 intermediate stops
Gröna Tåget 6 car average, including time margin

<table>
<thead>
<tr>
<th>Performance property</th>
<th>X 2000</th>
<th>Gröna Tåget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cant deficiency</td>
<td>245 mm</td>
<td>275 mm (10.8 in)</td>
</tr>
<tr>
<td>Top speed</td>
<td>200 km/h</td>
<td>250 km/h (155 mph)</td>
</tr>
<tr>
<td>Short-term tractive power</td>
<td>3.9 MW</td>
<td>6.0 MW</td>
</tr>
<tr>
<td>Starting acceleration</td>
<td>0.44 m/s²</td>
<td>0.6 m/s²</td>
</tr>
<tr>
<td>Running time (h:min)</td>
<td>3:07</td>
<td>2:51</td>
</tr>
</tbody>
</table>
Energy use

It is expected that energy use (per pass-km) will be reduced by 25-35 %, compared with present X 2000, despite higher speed because of

- improved aerodynamics + permanent magnet motor drives
- more energy regeneration and eco-driving
- improved space utilization + higher load factor
...Thank you for your kind attention