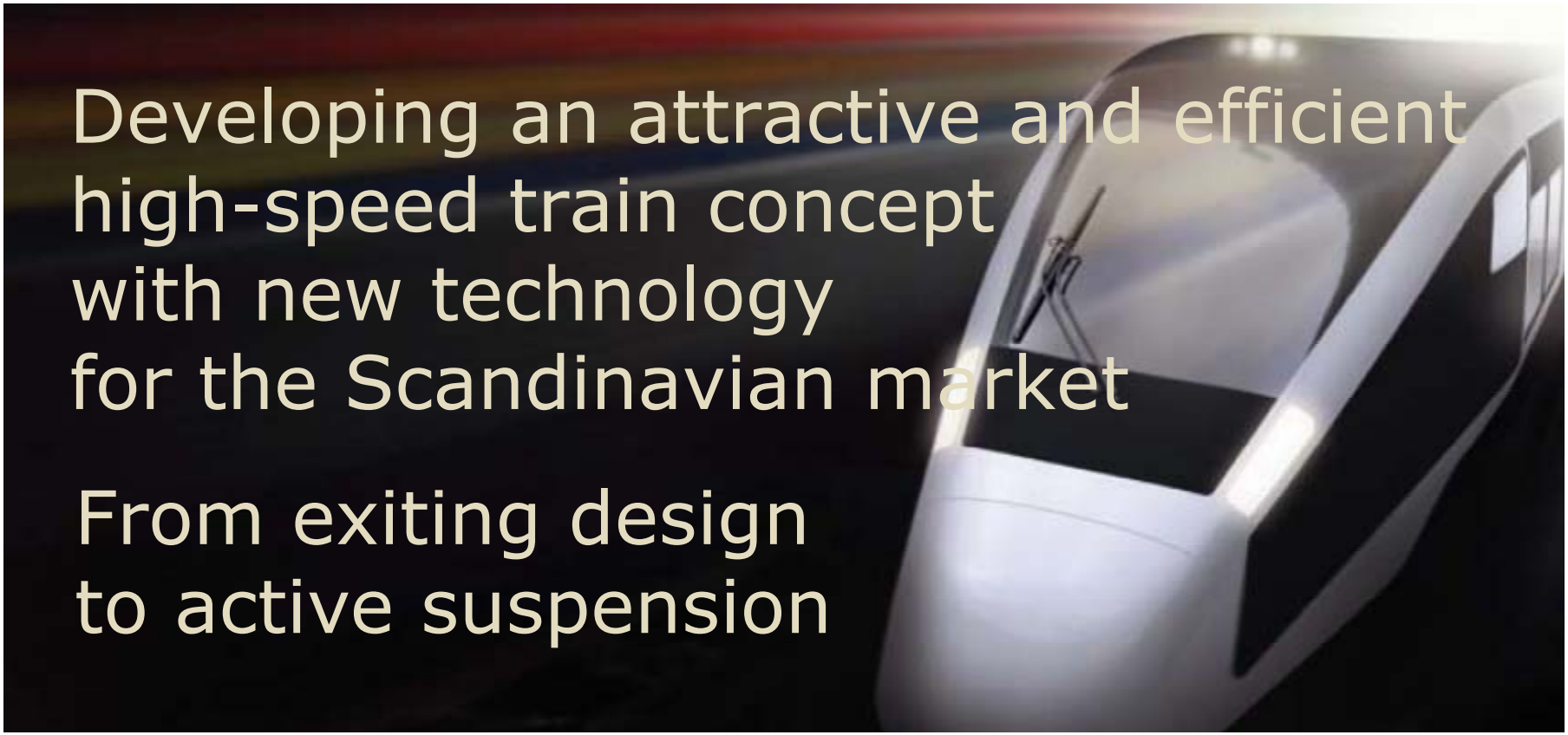
Gröna Tåget

Gröna Tåget
Trains for tomorrow's travellers

ROYAL INSTITUTE OF TECHNOLOGY



Evert Andersson, Gröna Tåget Project Manager
KTH Railway Group, Aeronautical & Vehicle engineering

17th Nordic Seminar, 3 October 2012

Partners in the research programme ”Gröna Tåget” (The Green Train) 2005-2012

ROYAL INSTITUTE OF TECHNOLOGY

Research and coordination

Branschföreningen Tågoperatörerna

CHALMERS

FLASH · HTML

TRANSITIO

Gröna Tåget

TRAFIKVERKET

the Swedish Transport Administration

Regina 250

BOMBARDIER

Interfleet Technology

transrail

VINNOVA

vti FINDING A BETTER WAY

and some more …

Total budget: 50+100 MSEK

ROYAL INSTITUTE OF TECHNOLOGY

What is Gröna Tåget?

”Gröna Tåget should serve as a bank of ideas, proposals and technical solutions for operators, infrastructure managers and industry”

- Attractive and functional for travellers
- Accessible for all – convenient entrances and luggage storage for avoiding delays at stations
- Reduced travel time – top speed ≥ 250 km/h + carbody tilt
- Many seats in a given train length – and very comfortable
- Low costs give profitability and lower ticket prices
- Track-friendliness, which means less wear to track and wheels and enables high speed on non-perfect track
- Even lower energy use and less noise than trains of today
- Reliability even in the Nordic winter climate

The most important ”green” effect is a high market share, because electric passenger trains are superior in environmental performance

ROYAL INSTITUTE OF TECHNOLOGY

The reference is *SJ 2000 (X 2000)*

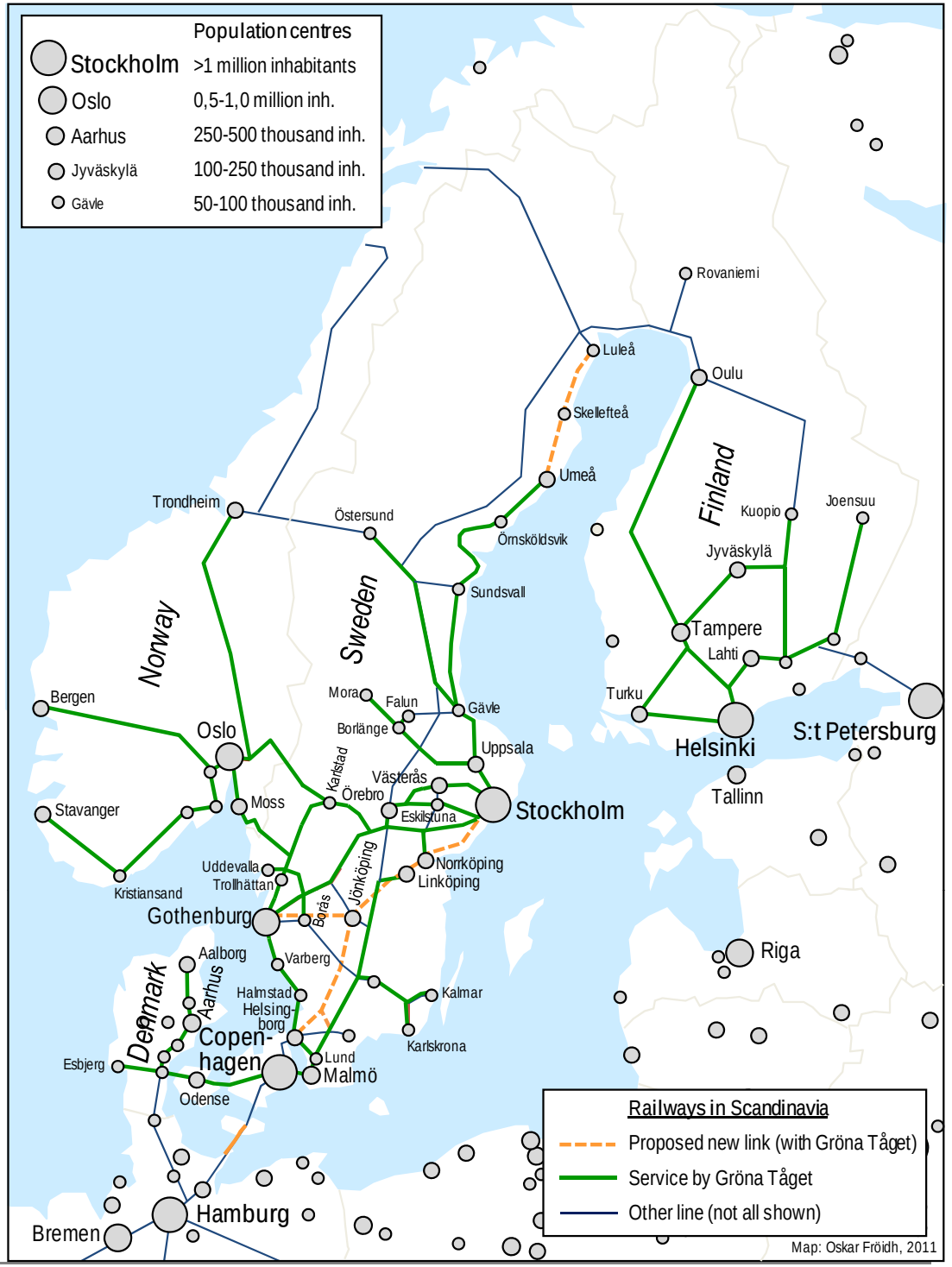
Reference: SJ 2000 (delivered1990-1998)

ROYAL INSTITUTE OF TECHNOLOGY

Possible lines with interoperable services in Scandinavia

- **Shorter travelling time on existing network (-10%)**
- **Also suitable for future high-speed lines**

Some infrastructure upgrading is necessary on existing lines (ERTMS, road crossings, catenary, platforms, capacity enhancements ....)



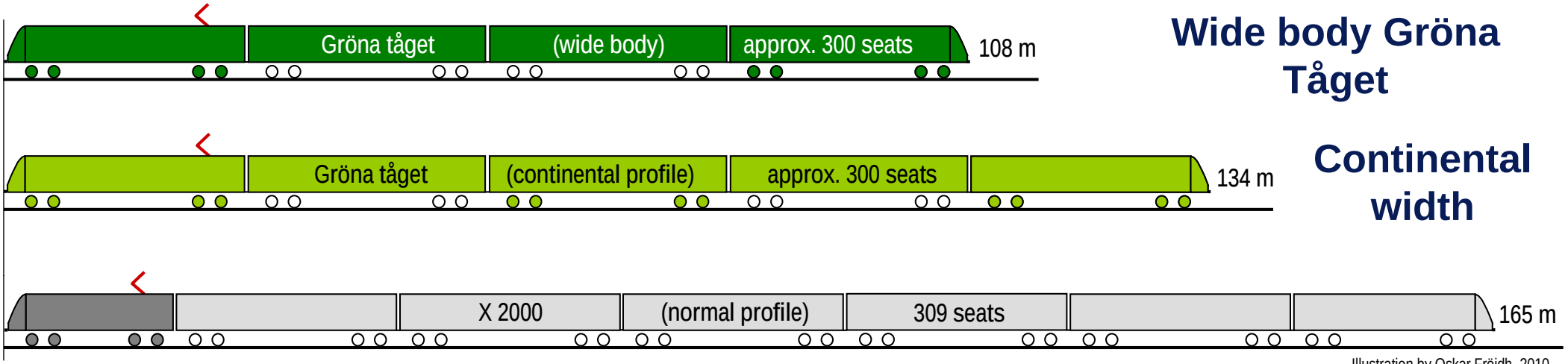
Travel time performance

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

Performance property	*SJ 2000*	*Gröna Tåget*
Cant deficiency	245 mm	275 mm (10.8 in)
Top speed	200 km/h	250 km/h (155 mph)
Short-term tractive power	3.9 MW	6.0 MW
Starting acceleration	0.44 m/s^2	0.6 m/s^2
Running time (h:min)	3:07	2:51

The Gröna Tåget concept

Small units (~ 300 seats) to run in multiple on demand (600-1000 seats)
- **Capacity** according to need (=> high load factor)
- **Different destinations** by coupling/uncoupling (avoiding train change)



Wide body Gröna Tåget

Continental width

Illustration by Oskar Fröidh, 2010

Present SJ 2000, 309 seats

Wide body (~3,3 m interior) allowing one more comfortable seat abreast will alone **reduce cost** (per seat-km) **by about 13 %.**

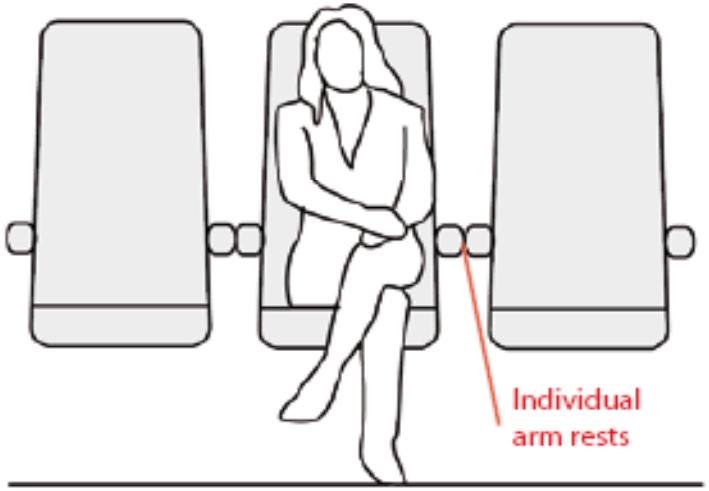
In total: About **25 % reduced cost** (per pass-km), compared SJ 2000

Attractive for travellers

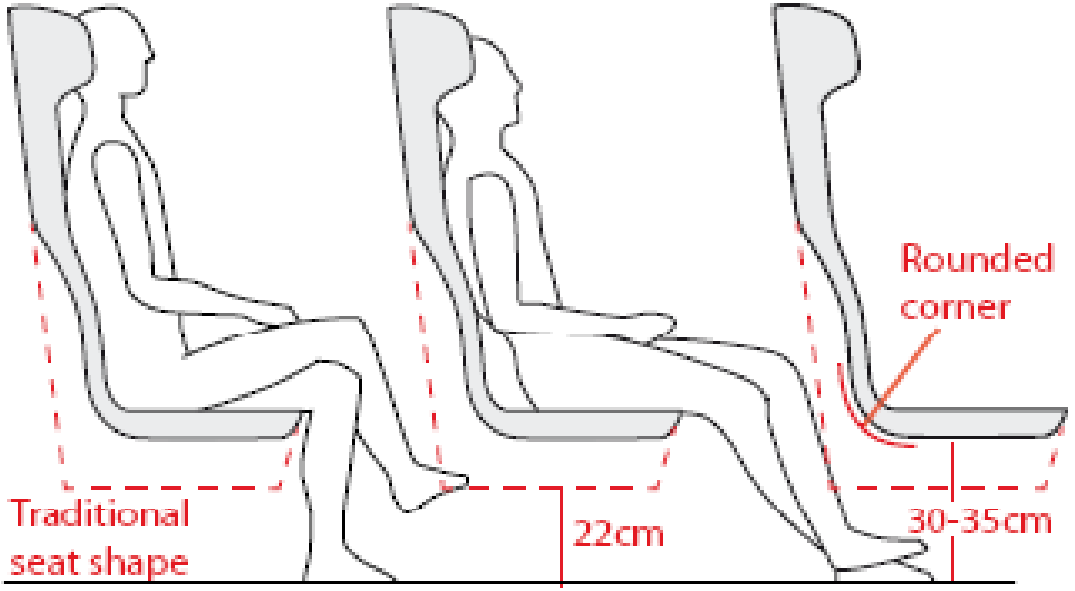
Research on traveller's preferences

Innovation

For comfort, functionality and space utilization (examples)



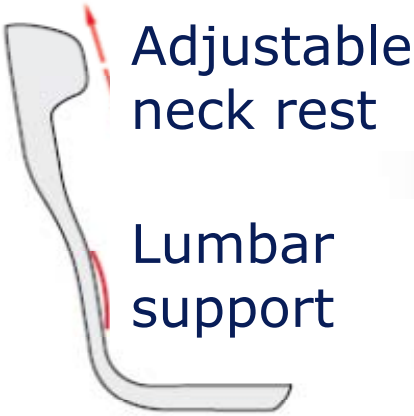
Individual armrests
very important for comfort



New **under-seat design** and **thin seatbacks**
allows some **15 % more seats**
with the same passenger acceptance.
A combination of higher comfort and more seats
is main alternative.

Further examples for attractiveness

Functionality and comfort for useful travel time



Head rests

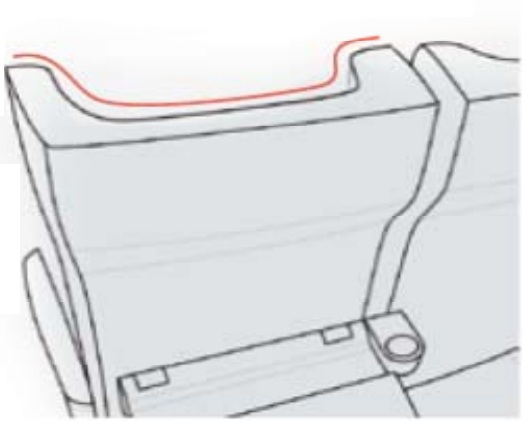
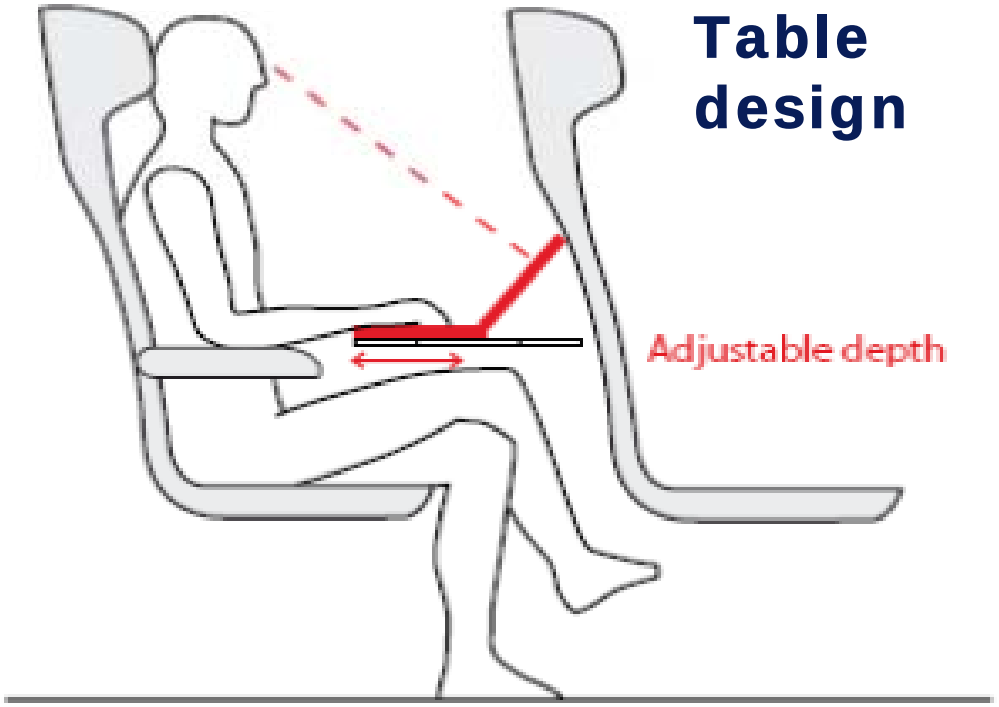


Table design



And a lot of other useful features
- **for clothes**
- **for luggage and prams**
- **etc**

Space for lap-top.
Adjustable table depth.
Edges to prevent fall-off.
Cup-holders.

Entrances and luggage

It is crucial that **boarding and alighting must take place within very tight margins.**

This is for **passenger comfort** and **punctuality** at station stops, in particular at ”family travelling” with lots of luggage.

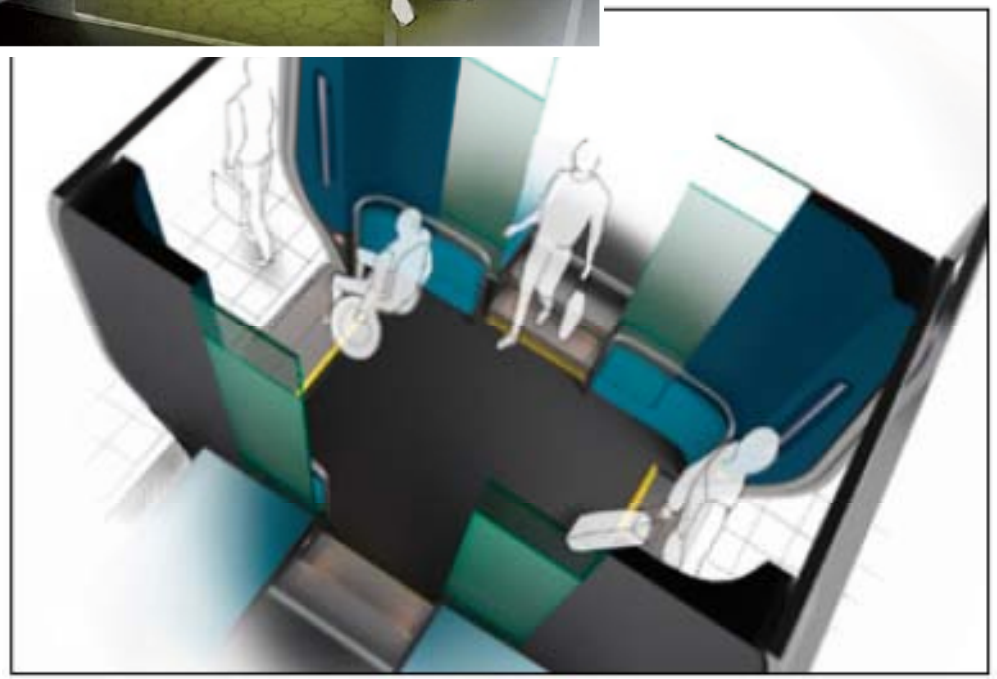
Punctual station stops without delays **increase the practical capacity** of the railway, and may compensate for the effect of increased difference in speed.

This means

- Doors, vestibules and aisles must be correctly dimensioned for continuous flow
- Luggage racks with high enough capacity
- Small an medium-sized luggage under and above seats
- Level entrance for handicapped, baby prams, etc

Exciting and functional design

Individual seat: WORK
Large foldable table, Internet / WLAN, personal reading light.



Concept of entrance, self adjusting to the platform height.

Testing of technologies
Bogies, noise, aerodynamics, propulsion, winter protection

Prototype and certification testing 2006 – 2008:

STEP 1
2006-07

Improved radial steered bogies (self-steering)

Bogie noise shield

New high-speed pantograph

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

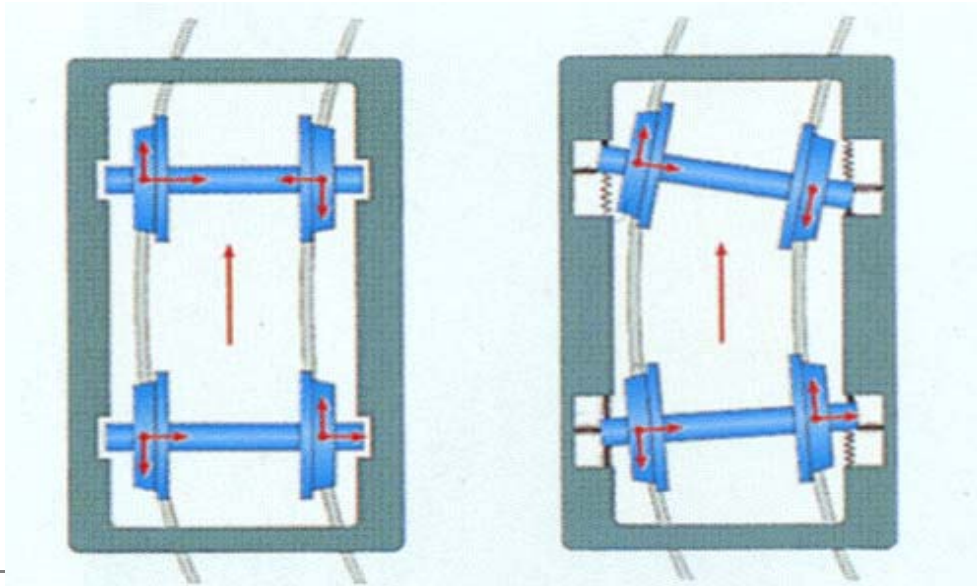
Endurance & reliability testing in revenue service (2009–2012)

Track friendly bogies and suspension

- **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.

Swedish speed record (303 km/h) on track standard for 160-200 km/h

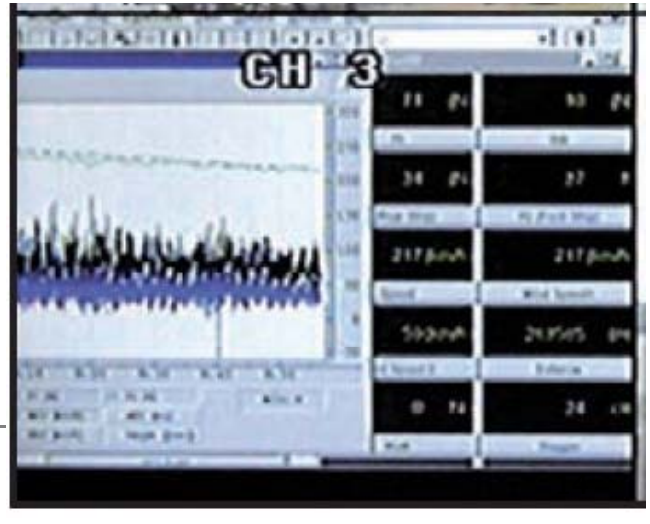


ROYAL INSTITUTE OF TECHNOLOGY

Propulsion and current collection

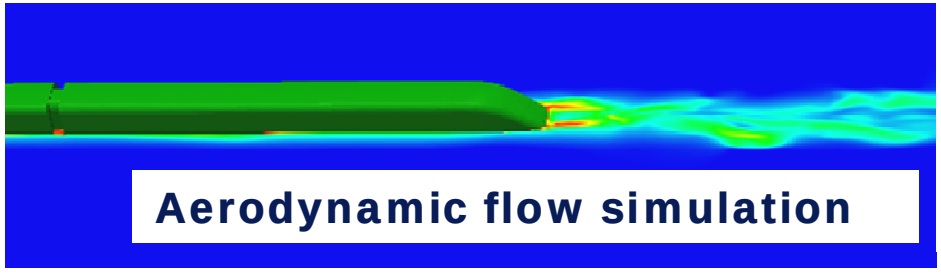
- **Permanent Magnet (PM) Motors** are successfully tested.
  Benefits are
  - Reduced losses, **higher energy efficiency**
  - **Reduced need for cooling**
  - **Reduced mass** and size; improved power/mass ratio.

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



Further studies and testing

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



Aerodynamic flow simulation

Test train
Modified ”Regina”

Winter testing

ROYAL INSTITUTE OF TECHNOLOGY

The climate challenge in Scandinavia

3-6 months average below zero
Occasionally –40°C
Heavy snowfall

Hundreds of measures must be applied compared to a "standard" high-speed train, in order to be able to operate in the low temperatures and snow conditions.

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

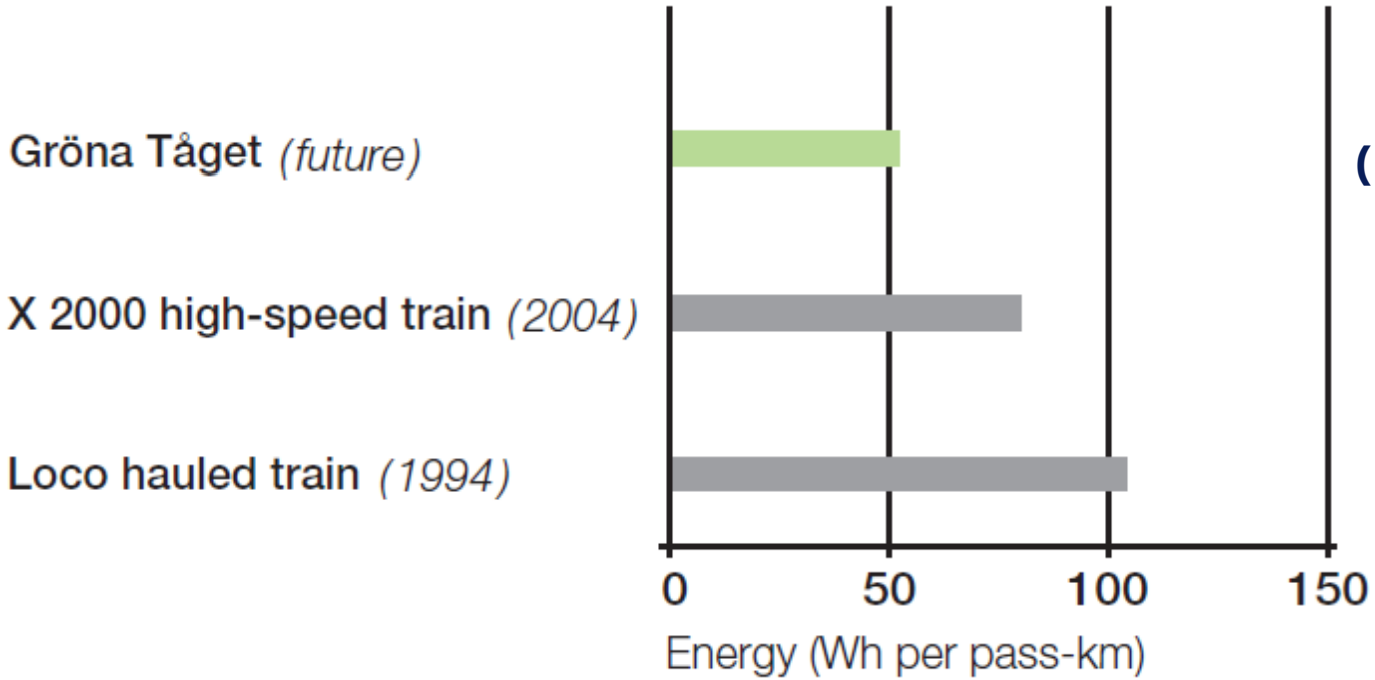
Bogie in snow

Sustainable passenger transport: Energy use

It is expected that **energy use** (per passenger-km)
will be **reduced by 25-35 %,**
compared with present *SJ 2000*, despite higher speed

This because of

- Improved **aerodynamics** + **permanent magnet** motor drives
- More **energy regeneration** and **eco-driving**
- Improved **space utilization** + **higher load factor**



5-10 g CO_2 per pass-km
(with Nordic electric power)

1 / 10 of ”miljöbil”

A holistic perspective

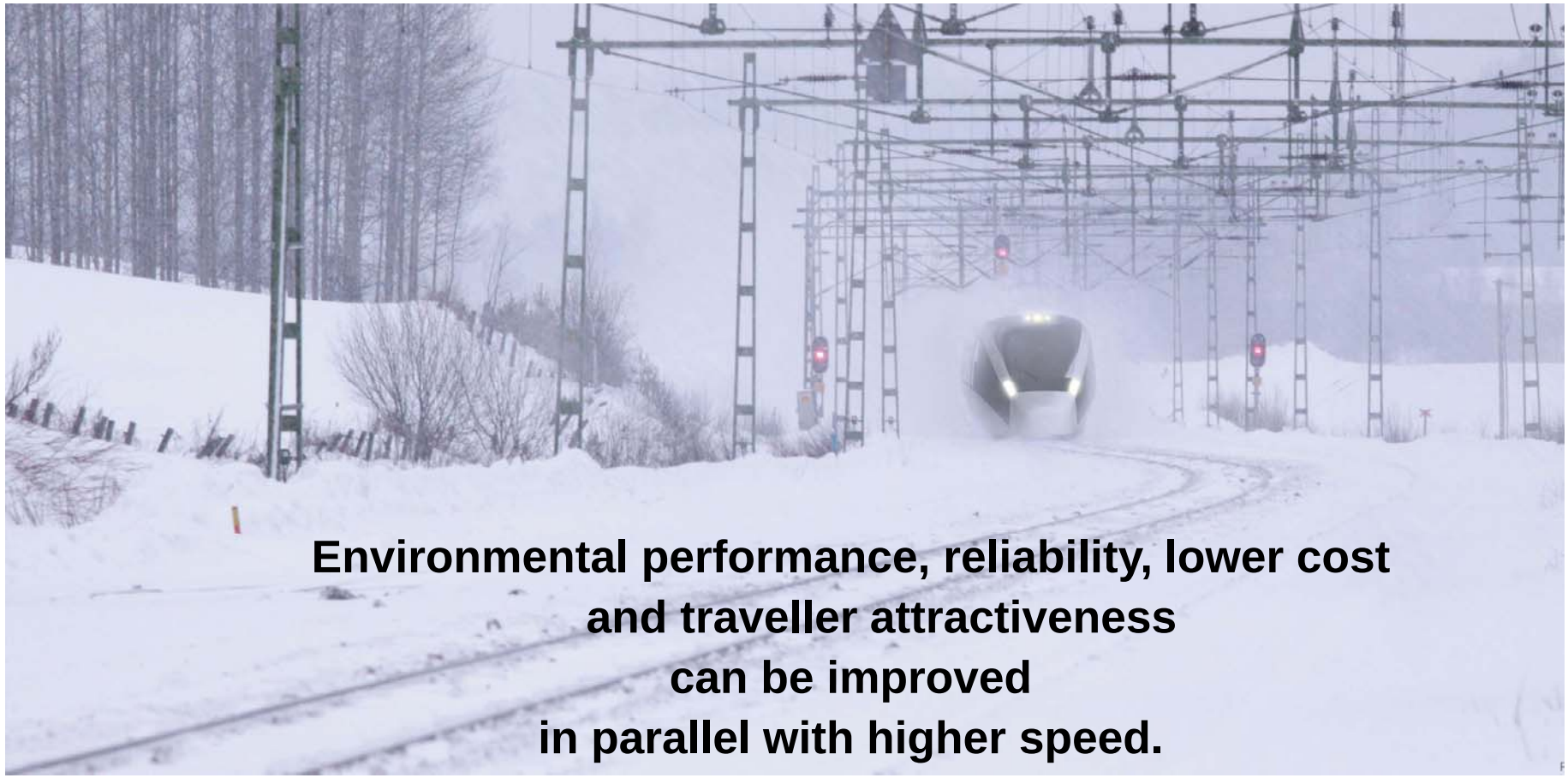
from exciting design to active suspension

A holistic perspective in research and analysis is necessary.

- Passenger comfort and convenience
  (seats, functionality, boarding and alighting, noise and vibration, motion sickness, exciting design …)
- Economy: Cost and prices
- Mixed rail traffic and capacity
- Optimum speed and travelling time (technical and economic)
- Passenger patronage
- Environment (energy, emissions, noise)
- Track friendliness (radial steering, active suspension)
- Reliability (in particular in Nordic winter, wild animals)
- Efficient propulsion, current collection, aerodynamics …
- Applicable standards and practices

Analysis, research, testing, co-operation

ROYAL INSTITUTE OF TECHNOLOGY



Environmental performance, reliability, lower cost and traveller attractiveness can be improved in parallel with higher speed.

A holistic perspective is necessary!

www.gronataget.se

Gröna Tåget
Trains for tomorrow's travellers

Evert Andersson
everta@kth.se