

Publication 0901

The KTH Railway Group

Status Report 2009



RV RAIL VEHICLES		RV RAIL VEHICLES		RV RAIL VEHICLES		SB STRUCTURAL DESIGN AND BRIDGES	
RV1	Running gear for freight wagons	RV10	Gröna Tåget – Programme Management	RV19	Technology opportunities and strategies toward climate-friendly transport (TOSCA)	SB1	Loads and Load Influence on Structures
RV2	Simulation of wheel-on-rail deterioration phenomena	RV11	Gröna Tåget – Track-friendly bogies	RV20	Lightweight carbody for high-speed trains	SB2	Long-term Monitoring and Assessment of Bridges
RV3	Modelling of rail vehicles dynamics	RV12	Gröna Tåget – High-speed vehicles with carbody tilt			SB3	A study of the dynamic interaction between train and bridge and the long-term changes in the dynamic properties of the new Årsta bridge
RV4	Track stiffness, irregularities and maintenance	RV13	Gröna Tåget – Sound quality of external railway noise			SB4	Efficient train systems for rail freight transportation
RV5	Dynamic instability and discomfort of high-speed trains due to aerodynamics in tunnels	RV14	Gröna Tåget – Energy consumption			SB5	Sustainable bridges
RV6	Robust safety systems of trains	RV15	Gröna Tåget – Active lateral suspension			SB6	Soil-Structure Interaction for Integral Bridges and Culverts
RV7	Simulation of energy consumption and running time of trains	RV16	Gröna Tåget – Overhead power systems for operation of high-speed trains in Sweden			SB7	Dynamic response of railway bridges subjected to high-speed trains
RV8	Train formation management and monitoring (TIMM)	RV17	Collaboration in research and development of new curriculum in sound and vibration (CIRCIS)			SB8	Bridge Weigh-in-motion for railway bridges
RV9	Crosswind stability and unsteady aerodynamics in vehicle design	RV18	Railway vehicle dynamics and track interactions: Total regulatory acceptance for the interoperable network (dynoTRAIN)			SB9	BRIDCAP – Increased load capacity of existing bridges on corridors

ToL TRANSPORTATION AND LOGISTICS		ToL TRANSPORTATION AND LOGISTICS		ToL TRANSPORTATION AND LOGISTICS		EP ELECTRIC POWER ENGINEERING	
Tol.1	Model for supply and costs for freight transport by rail	Tol.10	Gröna Tåget – market and services	Tol.19	Future infrastructure and train run quality	EP.1	New converter topologies for electric railway traction
Tol.2	Evaluation of intermodal transport chains	Tol.11	High-Speed Trains in Sweden – Supply and demand	Tol.20	Conquered infrastructure	EP.2	Dual system locomotives for rail freight transportation/ Drive cycles for freight locomotives
Tol.3	Effects of distance-based road-user fees for trucks	Tol.12	High-Speed Trains – a business approach and benefit to society	Tol.21	Timetable planning with simulation	EP.3	System aspects of Permanent magnet traction motors
Tol.4	Intermodal small-scale liner trains	Tol.13	Follow-up of travel demand along the Blekinge Coast line at supply changes	Tol.22	Simulation and capacity analysis	EP.4	Train information Management and Monitoring (TIMM)
Tol.5	TESS–Intermodal solutions for Trans European Temperature Sensitive Shipments	Tol.14	Car ownership model considering accessibility and public transport supply				
Tol.6	MINT–Model and decision Support System for Evaluation of Intermodal Terminal Networks	Tol.15	Public transport worth its price – effects on regional commuting				
Tol.7	FTCS – Freight Transport Corridor Study	Tol.16	Monetary valuation of ride comfort related to track quality			ME.1	Track-vehicle interaction (SAMBA6) – Wheel rail wear mechanisms and transitions
Tol.8	Other projects withing SiR-C	Tol.17	Database of supply and prices for railway lines in Sweden	MW MARCUS WALLENBERG LABORATORY FOR SOUND AND VIBRATION RESEARCH		ME.2	Adhesion between railway wheel and rail
Tol.9	New Opera and FERRMED	Tol.18	Other projects, papers and reports	MW.1	Gröna Tåget – noise and vibration part	ME.3	Airborne particles generated from train-track interaction

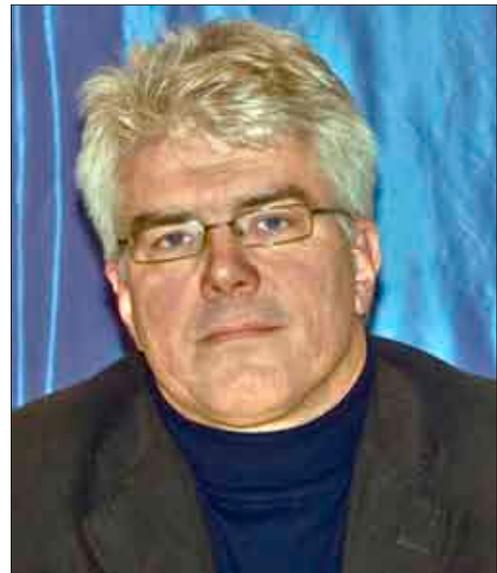


The KTH Railway Group in 2009

The KTH Railway was formed in the late eighties through a joint agreement between KTH, ABB, SJ, Banverket, Nutek, and the former Swedish Transport Research board. It is today one of Europe's leading university research groups in Railway Engineering. Presently we have more than 20 active senior researchers as well as 20+ PhD students. Today KTH has a long term agreement with Bombardier Transportation, the Swedish Train Operators, Banverket, Interfleet Technology and Stockholm Public Transport, SL.

The Status Report 2009 presents the status of ongoing projects and activities and replaces the previously published biannual reports. With this new status report we hope that we will be able to more continuously update information on projects and courses both in printed form and at www.railwaygroup.kth.se

This printed edition has been published in a great hurry and we know that there are many details that have to be corrected and added. However, that was a cost we had to pay to be able to present it at Nordic Rail 2009!



Professor Stefan Östlund, Director of the KTH Railway Group

The Board 2007–2009

The KTH Railway Group is organised as an independent unit within the School of Engineering Sciences. The board of the Railway Group consists of representatives from companies or organisations that have signed the general agreement.

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Railway courses in 2009–2010

SD2306 Spårtrafiksystem och Spårfordon (9 hp)
Railway Systems and Rail Vehicles

SD2313 Spårfordons dynamik (8 hp)
Rail Vehicle Dynamics

AH2026 Tågtrafik, marknad och planering, gk (7,5 hp)
Railway Traffic - Market and Planning, Basic Course

AH2028 Tågtrafik, marknad och planering, fk (7,5 hp)
Railway Traffic - Market and Planning, Advanced Course

AH2029 Järnväg signalteknik – signalsystem (7,5 hp)
Railway Signalling System, Basic Course

AH2030 Järnväg Systemsäkerhet, tillförlitliga system (7,5 hp)
Railway Signalling System – Reliability

AH2031 Järnväg signalteknik – projektering (7,5 hp)
Railway Signalling System - Project Planning

AH2032 Simulering av tågtrafik (7,5 hp)
Train Traffic Simulation

AF2901 Väg- och banteknik gk (7,5 hp)
Road- and Railway Track Engineering

AF2904 Väg- och banteknik fk (7,5 hp)
Advanced Pavement Engineering Analysis and Design

EJ2400 Elektrisk traktion (7,5 hp)
Electric Traction

In addition we teach a number of courses for professional engineers. More information is provided at

www.railwaygroup.kth.se

or at the web page of each of the courses at

www.kth.se/student/kurser/kurs/kurskod

where "kurskod" is replaced by the number of each course respectively, e.g. SD2306.



PhD theses at the KTH Railway Group 1995–2009

1. Anders Nordborg: Vertical rail vibrations - Noise and structure-born sound generation, 1995.
2. Raid Karoumi, Response of Cable-Stayed and Suspension Bridges to Moving Vehicles, Analysis methods and practical modeling techniques, 1998,
3. Karl Kottenhoff: Evaluation of passenger train concepts – methods and results of measuring travellers' preferences in relation to costs, 1999.
4. Eckart Nipp: Permanent magnet motor drives with switched stator windings, 1999.
5. Johan Förstberg: Ride comfort and motion sickness in tilting trains – Human responses to motion environments in train and simulator experiments, 2000.
6. Pelle Carlbom: Carbody and passengers in rail vehicle dynamics, 2000.
7. Romain Haettel, Vibration Transmission in Plate Structures - Special Application to Train Car Bodies, 2000
8. Björn Kufver: Optimisation of horizontal alignments in railways – Procedures involving evaluation of dynamic vehicle response, 2000.
9. Robert Hildebrand: Countermeasures Against Railway Ground and Track Vibrations, 2001
10. Piotr Lukaszewicz: Energy consumption and running time for trains – Modelling of running resistance and driver behaviour based on full scale testing, 2001.
11. Peter Kjellqvist: Modelling and design of electromechanical actuators for active suspension in rail vehicles, 2002.
12. Gerard James, Analysis of Traffic Load Effects on Railway Bridges., 2003,
13. Tanel Telliskivi: Wheel-Rail Interaction Analysis, 2003
14. Oskar Fröidh: Introduction of regional high-speed trains – A study of the effects of the Svealand line on the travel market, travel behaviour and accessibility, 2003.
15. Staffan Norrga: On soft-switching isolated AC/DC Converters without Auxiliary Circuit, 2005.
16. Rickard Nilsson: On wear in rolling/sliding contacts, 2005
17. Jerker Sundström: Difficulties to read and write under lateral vibration exposure – Contextual studies of train passengers' ride comfort, 2006.
18. Ben Diedrichs: Studies of two aerodynamic effects on high-speed trains: Crosswind stability and discomforting car body vibrations in tunnels, 2006.
19. Roger Enblom: On simulation of uniform wear and profile evolution in the wheel-rail contact, 2006.
20. Nizar Chaar: Wheelset structural flexibility and track flexibility in vehicle-track dynamic interaction, 2007.
21. Per-Anders Jönsson: Dynamic vehicle-track interaction of European standard freight wagons with link suspension, 2007.
22. Dan Brabie: On derailment-worthiness in rail vehicle design – Analysis of vehicle features influencing derailment processes and consequences, 2007.
23. Eric Berggren: Railway track stiffness – Dynamic measurements and evaluation for efficient maintenance, 2009.
24. Gerhard Troche: Activity-based rail freight costing – A model for calculating transport costs in different production systems, 2009.
25. Tommy Kjellqvist: On design of a compact primary switched conversion system for electric railway propulsion, 2009.



Rail Vehicles – RV

The activities at the Division of Rail Vehicles mainly focus on rail vehicles and their dynamic interaction with the track. Research is also carried out on topics like sound and vibration from a railway passenger perspective, and on

energy consumption and running times. In addition, the division is responsible for two undergraduate courses and external courses.

RESEARCH PROJECTS

RV1. Running gear for freight wagons

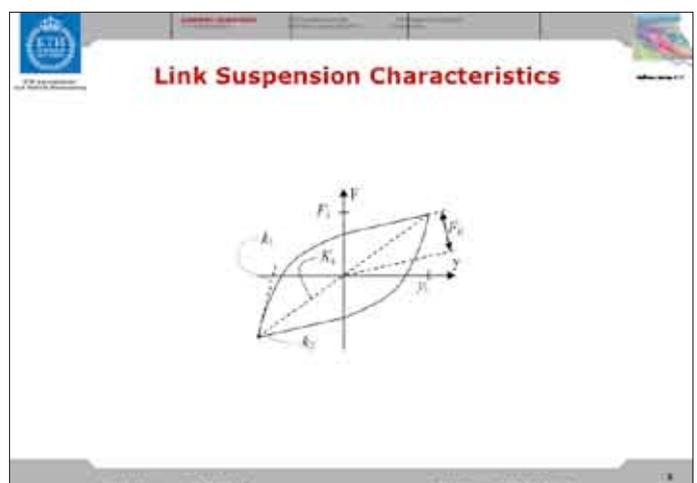
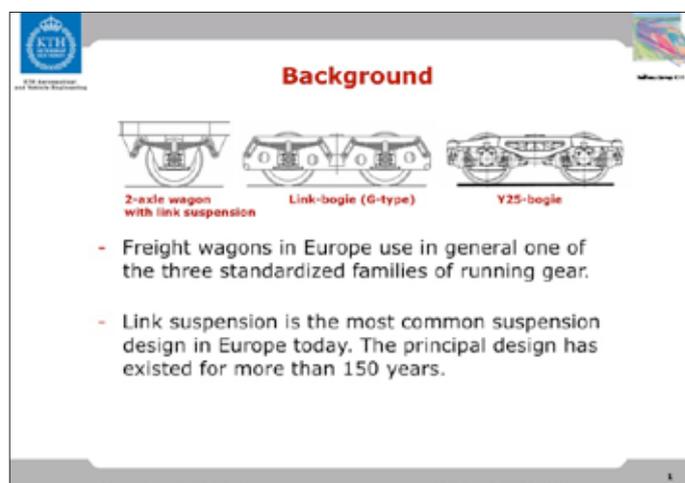
Project leader Sebastian Stichel
Scientists Per-Anders Jönsson
 Sebastian Stichel
 Evert Andersson

Sources of funding: Banverket, Bombardier Transportation, SL AB, Tågoperatörerna, Interfleet Technology.

The European standardised designs of freight wagons and their running gear are 40–50 years old. To increase competitiveness of freight transport on rail it is desired to increase axle load and/or speeds, but this would - at least for some operating conditions for standard running gear

- mean to exceed existing limit values for ride quality and wheel-rail forces. At least as important is to improve ride qualities in order to reduce damages on transported goods and being able to attract customers that require transport service for sensitive and high-value goods.

The project is firstly aimed to study and learn how freight wagons behave dynamically on track. This is made both for standardised running gear and for novel designs. The second step is to analyse and test possible improvements in the designs, in particular the standardised designs now dominating in Europe. In the project special attention is given to the very common link suspensions, their characteristics and the possible effects on variations in



the characteristics. Substantial improvements by means of additional hydraulic dampers have been suggested and tested on modified two- and four-axled wagons on track. Speeds up to 170 km/h have been tested. A third part of this project is to investigate the causes of track deterioration and to propose mathematical models for prediction of deterioration.

The project ended summer 2007, when Per-Anders Jönsson successfully defended his PhD thesis. However, it is intended to continue with research on freight wagon dynamics also in the future. Main goal will be to suggest solutions which reduce maintenance costs for freight traffic to increase competitiveness against other modes of transport.

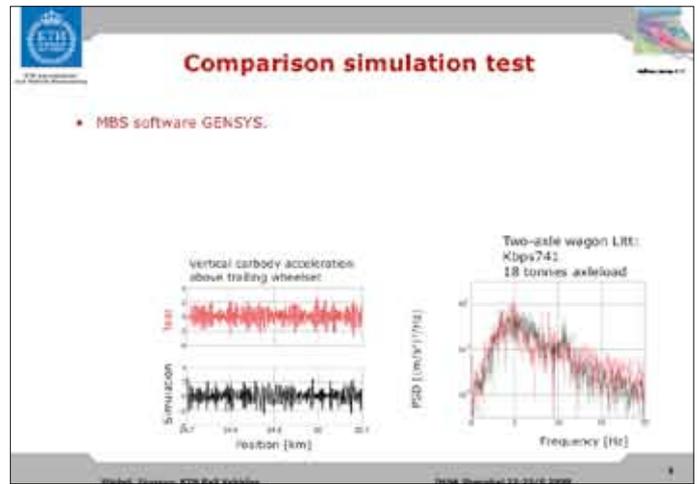
Jönsson P.-A., Stichel, S.: Improving Ride Comfort in Freight Wagons with Link Suspension Running Gear using Hydraulic Dampers. ZEV+DET Glas. Annalen 131, Juni, p. 230-240, 2007.

Jönsson P.-A., Stichel, S.: On the Influence of Freight Traffic Operational Conditions on Track Deterioration cost. Proceedings of International Heavy Haul Conference, p 445-452, Kiruna, June 11-13, 2007.

Jönsson P.-A., Persson I. Stichel, S.: New Simulation Model for Freight Wagons with UIC Link Suspension. Vehicle System Dynamics, Volume 46, Supplement, pp 695-704, 2008.

Andersson E and Öberg J: Models for infrastructure costs related to the wheel-rail interface. Accepted for publication in Wheel-rail Interface Handbook, Woodhead Publishing Ltd, Cambridge, England, 2009.

Öberg J and Andersson E: Determining Deterioration Cost for Railway Tracks. Accepted for publication in Journal of Rail and Rapid Transit.



RV2. Simulation of Wheel-On-Rail Deterioration phenomena (SWORD)

Project leader Roger Enblom
Scientists Babette Dirks
Roger Enblom
Mats Berg

Sources of funding: Banverket, Bombardier Transportation, SL AB, Tågoperatörerna, Interfleet Technology

The project was started in May 2008 with the employment of Babette Dirks as Ph.D. student.

The research focus is on damage prediction in the wheel–rail interface. The contact patch is small and subjected to high stresses and wear. Two common modes of deterioration, causing significant maintenance costs, are wear and fatigue. In addition the vehicle–track interaction may be influenced in the direction of decreasing dynamic performance. The prevailing mode of deterioration is determined by load and operating conditions. The challenge is to develop and integrate methods for prediction of wear and rolling contact fatigue (RCF) – in reality mutually dependent phenomena. Initiated cracks may be worn away and the contact geometry may be altered, changing the rate of crack propagation.

The objective is to create a model for prediction of the total expected life of wheels or rails with respect to both fatigue cracking and wear, practically applicable and resting on a firm scientific foundation. For model validation, access to results in terms of real damage investigations and laboratory tests, mainly carried out by other research projects or the industry, is anticipated.

The prediction methodology is based on recent achievements in wear and RCF modelling. Multi-body simulations (MBS) of the interaction between vehicle and track by using commercially available software provide input to the tribological models. The real operation conditions are emulated by defining an adequate set of simulations.

For a successful simulation of the wear – fatigue trade-off it is believed that adequate models for contact stress, local slip, material loss, fatigue damage, and possibly plastic material flow are needed.

- In the area of contact mechanics the intended starting point is investigation and adaptation of available non-Hertzian models, able to describe the typical geometry of the wheel-rail contact.
- When it comes to material loss modelling, the path forward may be further development and validation of the Archard approach with emphasis on lubricated contacts and poor adhesion conditions.

- For assessing the fatigue damage, a quantitative damage accumulation rate is needed. The purpose is to determine the prevailing damage mechanism for actual contact conditions.
- If found critical, some model for plastic material relocation should be considered.

In the first paper available models for prediction of rolling contact fatigue are evaluated and some trial simulations and parameter studies are reported.

Dirks B and Enblom R, Prediction model for wheel profile wear and rolling contact fatigue, Presented at the 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, Firenze, 15-18 September, 2009.

The preceding project in this area, "Wear on wheels and rails" (SAMBA 2) was essentially finished in 2006 with the Ph.D. thesis of Roger Enblom:

Enblom R, On simulation of uniform wear and profile evolution in the wheel-Rail Contact, Ph.D. Thesis, TRITA AVE 2006:83, KTH Rail Vehicles, 2006. ISBN 978-91-7178-605-3.

Since then, the following papers have been published:

Enblom R, Berg M, Impact of non-elliptic contact modelling in wheel wear simulation, *Wear*, vol 265, pp 1532-1541, 2008.

Enblom R, Berg M, Proposed procedure and trial simulation of rail profile evolution due to uniform wear, *Proc. IMechE Vol 222/1 Part F: J. Rail and Rapid Transit*, pp. 15-25, 2008.

Enblom R, Deterioration mechanisms in the wheel-rail interface with focus on wear prediction: a literature review, *Vehicle System Dynamics*, Electronically published 07 January 2009.

RV6. Robust safety systems for trains

Project leader Evert Andersson
Scientists Dan Brabie

Brabie D and Andersson E: Analysis of vehicle features influencing train derailment processes and consequences. 38. Tagung Moderne Schienenfahrzeuge, Graz, September 2008. Also published as proceedings in ZEVrail, Vol 132 (2008), Tagungsband SFT.

Sources of funding: Banverket, Bombardier Transportation, SL AB, SJ, Green Cargo, Vinnova
This research project aims at systematically studying the possibilities of minimizing devastating consequences of high-speed derailments by appropriate measures and features in the train design. In particular the cause of events immediately after a mechanical failure on axles, wheels, rails or similar is studied, e.g. whether the train stays upright close to the track centre or deviates laterally with probably serious consequences. Conclusions are drawn from an interactive process where multi-body computer simulations are performed and compared with real incidents and accidents. Different train design parameters are systematically investigated by means of in this way validated simulation models. The vehicle behaviour associated with derailments is taken into consideration through a newly developed multi-body system post-derailment module, capable of predicting the dynamic motion of wheelsets rolling and bouncing on concrete sleepers.

The project continued until January 2008.

Brabie D and Andersson E: An overview of some high-speed train derailments - means of minimizing consequences based on empirical observations. *Journal of Rail and Rapid Transit*, Vol 222, p 441-463, 2008.

Brabie D and Andersson E: On minimizing derailment risks and consequences of passenger trains at higher speeds, submitted for publication in *Journal of Rail and Rapid Transit*.

Brabie D: Wheel-Sleeper Impact Model in Rail Vehicle Analysis, *Journal of System Design and Dynamics*, Vol. 1, Nr. 3, pp 468-480, On-line ISSN 1881-3046, 2007.

Brabie D and Andersson E: Post-derailment dynamic simulations of rail vehicles - Methodology and applications, Presented at the 20th IAVSD Symposium on Dynamics of Vehicles on Roads and Tracks, Berkeley, CA, 13-17 August, 2007.

Brabie D and Andersson E: Means of minimizing post-derailment consequences by alternative guidance mechanisms, BOGIE'07, Budapest, 3-6 September, 2007. Proceedings of the 7th International Conference on Railway Bogies and Running Gears.

Brabie D: On Derailment-Worthiness in Rail Vehicle Design - Analysis of vehicle features influencing derailment processes and consequences, Doctoral Thesis, TRITA AVE 2007:78, Division of Rail Vehicles, Royal Institute of Technology (KTH), Stockholm, 2007. ISBN 978-91-7178-828-3.

Brabie D and Andersson E: High-speed Train Derailments - Minimizing consequences through innovative design. World Congress of railway Research (WCRR'08), Seoul, Korea, May 18-22, 2008.

Brabie D and Andersson E: Vehicle features minimizing consequences of a train derailment. 15:e Nordiska seminarieret för Järnvägsteknik, Hook, 22-23 maj 2008.

RV10. Gröna Tåget (Green Train) : Programme management

Research leader Evert Andersson

Sources of funding: Banverket

The “Green Train” is a multi-disciplinary research and development program involving several members of the KTH Railway Group. KTH is performing research on selected topics and is also appointed as total programme manager. The programme also involves several other members of the Swedish railway sector, such as Banverket, Bombardier Transportation, Tågoperatörerna (The Association of Swedish Train Operators), Transitio, VTI and CHARMEC, as well as some consultants as Interfleet Technology, Transrail and Ferroplan. The public funded part constitutes some 50 MSEK (5 MEUR) besides still higher contributions from industry (as decided at the end of 2007). The duration is from 2005 to 2011.

The overall aim is to safeguard and further develop the knowledge required for specification and development of a new generation high-speed train for Swedish (Nordic) conditions – fast and attractive, economically viable and still friendlier to the environment. The top speed is aimed for 250-300 km/h, running both on the existing Swedish rail network and on future high-speed lines.

Andersson E: Vad är grönt i Gröna Tåget – vårt framtida attraktiva snabbtåg? Transportforum, Linköping, 2007.

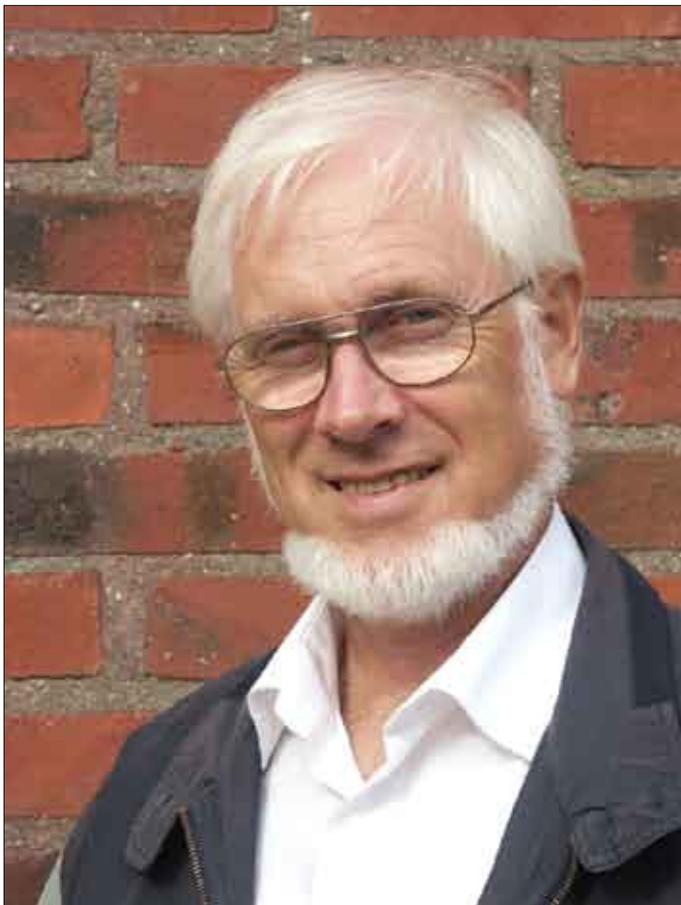
Andersson E: Vad gör vi – och varför? Nordic Rail, Jönköping, okt 2007.

Andersson E and Fröidh O: Goda tider kan ge snabbare resa. Nordisk Järnbane tidskrift, Nr 1 2008

Andersson E: Gröna Tåget: Varför? Krav och mål. Vad har vi gjort? Preliminära resultat hittills. Vad planerar vi? 15:e Nordiska seminarier för järnvägsteknik, Hook, 22-23 maj 2008.

Andersson E: Gröna Tåget: Varför? Krav och mål. Vad har vi gjort? Preliminära resultat hittills. Vad planerar vi? Föredrag för NJS Stockholm, 12 nov, 2008.

Andersson E: Gröna Tåget: Varför? Krav och mål. Vad har vi gjort? Preliminära resultat hittills. Vad planerar vi? Föredrag för Swedish Rail Industry Group (SWERIG), Stockholm, 2 dec 2008.



Research leader Professor Evert Andersson

RV11. Gröna Tåget: Track-friendly bogies

Project leader Evert Andersson
Scientists Anneli Orvnäs
Rickard Persson
Evert Andersson

Sources of funding: Banverket

Investigation and specification of appropriate suspension parameters for radial self-steering high-speed bogies. The aim is to contribute to the development of bogies allowing a high degree of passenger comfort, dynamic stability at high speed, moderate track forces and a low wheel-rail wear in curves. This is made by an extensive set of multi-body simulations taking a large number of possible track conditions into account. During summers 2006-08 these developments were successfully tested on various straight and curved tracks in Sweden. A Swedish speed-record of 303 km/h was set in Sep 2008, on a conventional Swedish track for 200 km/h.

Orvnäs A, Andersson E and Persson R: Development of Track-Friendly Bogies for High Speed – A simulation Study, KTH Railway Group, Publ 0703, ISBN 978-91-7178-726-2.

Andersson E, Orvnäs A and Persson R: Radial Self-Steering Bogies – Development, Advantages and Limitations, ZEV+DET Glasers Annalen, June 2007 (proceedings from “Moderne Schienenfahrzeuge”, Graz, April 2007).

Andersson E, Orvnäs A and Persson R: Radial Self-Steering Bogies - Recent Developments for High Speed, BOGIE'07, 3-6 September 2007, Budapest. Proceedings of the 7th International Conference on Railway Bogies and Running Gears.

Orvnäs A: Development of Track-Friendly Bogies for High Speed, SIMPACK News, Vol.11, Second Issue, November 2007.

Persson R: Spårvänliga fordon principer och fördelar, Nordic Rail, Jönköping, okt 2007.



The Regina prototype train

RV12. Gröna Tåget: High-speed vehicles with carbody tilt

Project leader Evert Andersson
Mats Berg
Scientists Rickard Persson
Evert Andersson
Mats Berg
Björn Kufver

Sources of funding: Banverket, VTI, Vinnova, KTH
Railway Group

This project aims at investigating possibilities for improved performance of rail vehicles equipped with a carbody tilt system. Firstly a review is made on state-of-the-art in this field, followed by an analysis of suitable cases for tilted rail vehicles. At the second stage a thorough analysis is made on possible causes for motion sickness in tilting trains, presently being a major limitation of tilted vehicles. Also suitable improvements in the vehicle technology should be outlined, as well as suggestions for suitable track geometry parameters.

Persson R: Spårvänliga boggier och korglutning, Transportforum 2007.

Persson R: Tilting Trains – Description and analysis of the present situation. Publ 0702, Railway Group KTH, Stockholm 2007, ISBN 978-91-7178-608-1.

Persson R: Identification of areas where the competitiveness of tilting trains can be further improved, Railway Engineering 2007.

Persson R: Research on the competitiveness of tilting trains, Railway Engineering 2007.

Persson R: Korglutning - behövs det? Nordic Rail, Jönköping, October 9-11, 2007.

Persson R: Motion sickness in tilting trains – Description and analysis of the present knowledge. Publ 0801, Railway Group KTH, Stockholm 2008, ISBN 978-91-7178-680-3.

Persson R: Tilting trains – Technology, benefits and motion sickness. Licentiate thesis, KTH Dept of Aeronautical and Vehicle Engineering, Stockholm 2008. ISBN 978-91-7178-972-3.



Project leader Professor Mats Berg

RV13. Gröna Tåget: Sound quality of external railway noise

Project leader Shafiq Khan
Scientists Shafiq Khan
Jerker Sundström
Evert Andersson

Sources of funding: Banverket and VTI

In this project a study is made on human annoyance of different characters of railway noise, as radiated to the surrounding environment. This is made by recording sound (noise) from different types of trains and subsequently exposing these noises to human test subjects in a laboratory. The latter noises are normalized with respect to duration and A-weighted sound pressure level. The results so far show that there are significant differences in human annoyance from different characters of railway noise, although all these noises have the same A-weighted sound pressure level.

Khan S: Sound quality of railway noise with and without barrier – a laboratory study, Proceedings of 19th International Congress on Acoustics (ICA), September 2007.

RV14. Gröna Tåget: Energy consumption

Project leader Piotr Lukaszewicz
Scientists Piotr Lukaszewicz
Evert Andersson

Sources of funding: Banverket

Possible levels of energy consumption - per seat-km or per passenger-km - have been estimated for future high-speed trains, in particular for the Green Train concept. The study shows that appropriate train design makes it possible to reduce energy consumption by 25 – 40 % both on the existing railway network and on future high-speed lines - despite shorter travel time and higher speeds.

Andersson E: Gröna Tåget, morgondagens snabbtåg. Hur kan energiförbrukning och CO₂-utsläpp reduceras? Invited speaker, NJS konferens "Jernbaner og CO₂", Köpenhamn, 31 okt 2008.

Detailed research report to appear.

RV15. Gröna Tåget: Active lateral suspension

Project leader Sebastian Stichel
Scientists Anneli Orvnäs
 Rickard Persson
 Sebastian Stichel

Sources of funding: Banverket

At increased rail vehicle speed it may be difficult to maintain acceptable passenger ride comfort with conventional passive secondary suspension. Within this project in co-operation with Bombardier Transportation it is investigated whether active technology is able to maintain good passenger comfort although vehicle speed is increased and track conditions are worse.

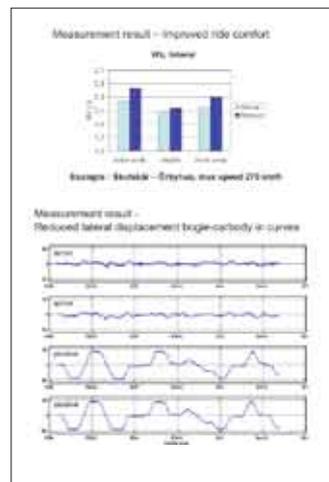
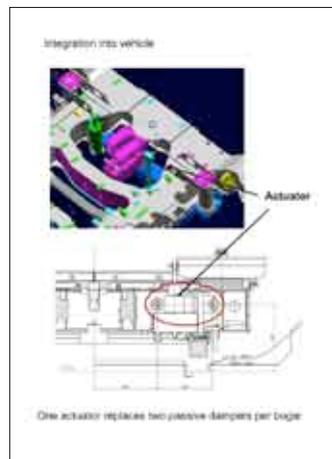
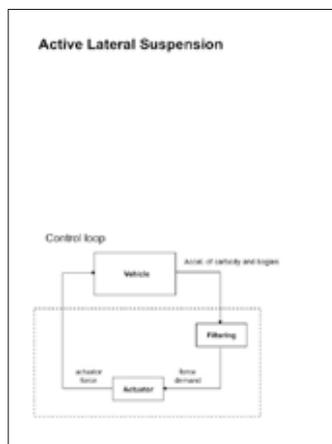
The possibility of reducing travel in the lateral suspension – and thus allowing a wider carbody within the prescribed dynamic envelope – is also investigated. After design

studies with help of computer simulation, on-track tests have been performed with an active lateral secondary suspension concept implemented in a two-car Regina train during the summers of 2007 and 2008. The evaluated measurement results are encouraging and the device will be implemented in long-term tests in service operation, which will be carried out in the beginning of 2009.

Orvnäs, A., Stichel, S. and Persson, R.: Improving Ride Comfort in Trains with Active Suspension. 15:e Nordiska Seminariet i Järnvägsteknik, Jönköping, May 23, 2007.

Orvnäs, A., Stichel, S. and Persson, R.: On-Track Tests with Active Lateral Secondary Suspension: A Measure to Improve Ride Comfort, ZEVrail Glasers Annalen 132, No 11-12, pp. 469-477, 2008.

Orvnäs, A: Active lateral secondary suspension in a high-speed train to improve ride comfort, Licentiate thesis, KTH Dept of Aeronautical and Vehicle Engineering, Stockholm 2009. ISBN 978-91-7415-300-2.



- Findings**
- ALS significantly improves lateral ride comfort
 - ALS has only minor influence on track forces
 - The test train with ALS is approved for a maximum speed of 250 km/h
 - Long-term tests in service operation are being carried out since March 2009

RV16. Gröna Tåget: Overhead power systems for operation of high-speed trains in Sweden

Project leader Sebastian Stichel
Scientists Sebastian Stichel
Lars Drugge
Mats Berg

Sources of funding: Banverket

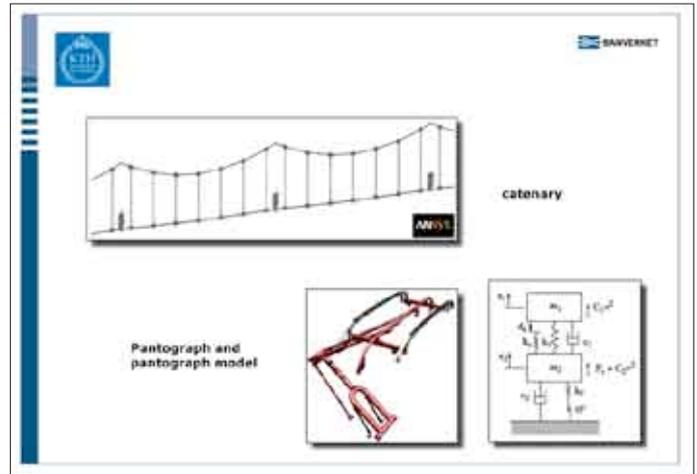
The overhead power system has been identified as one of the critical areas when increasing train speed.

Several questions can not be answered today:

- Which performance do pantograph, catenary and traction system need to have - especially in case of multiple units?
- Does the maximum speed need to be limited in case of more than one pantograph with short distance between each other? The issue does not exist in the same way for other European high speed traffic since the trainsets and thus the distance between pantographs are significantly longer e.g. in Germany or France.

- Could active pantographs work at the desired speed without changing the catenary system?

Within the project the dynamic interaction pantograph/catenary will be studied mainly by use of computer simulation. Existing measurement results shall be used as long as possible. During the on track test summer 2008 further measurements were carried out.





Structural Design and Bridges – SB

The division is conducting research and education within railway track engineering including bridges and tunnels.

They are also responsible for co-ordination of issues concerning the railway infrastructure.

Personnel

Professor	Håkan Sundquist	hakan.sundquist@byv.kth.se
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	Mahir Ülker-Kaustell, M.Sc.	mahir.ulker@byv.kth.se

RESEARCH PROJECTS

SB1. Loads and Load Influence on Structures

Researchers Raid Karoumi
 Gerard James

Source of Funding: Johnson Foundation, KTH, Swedish National Road Administration (Vägverket), Swedish National Rail Administration (Banverket).

The project deals with studies of the dynamic response of bridges subjected to moving vehicles. Measurement methods for loading on railway and road bridges are examined. Bridge weigh-in-motion systems including interpretation of statistical results are developed.

James G, Karoumi R, Kullberg C and Trillkott S, Measuring the Dynamic Properties of Bridges on the Bothnia Line, TRITA-BKN Report 92, Brobyggnad, 2005.

Guidelines for Railway Bridge Dynamic Measurements and Calculations, UIC leaflet, Union Internationale des Chemins de Fer, Version 1, January, 2006. (Edited by Karoumi R.)

SB 2. Long-term Monitoring and Assessment of Bridges

Researchers Håkan Sundquist
 Merit Enckell
 Richard Malm

The aim of the project is the long-term monitoring of railway bridges. The project is designed to compare traditional monitoring techniques with the relatively new fibre optic measuring systems and assess their behaviour over long measuring periods. The project is also intended to increase the understanding of the dynamic behaviour of railway bridges.

Malm R, James G, Sundquist H, Monitoring and evaluation of shear crack initiation and propagation in webs of concrete box-girder sections, The International Conference on Bridge Engineering – Challenges in the 21st Century, November 1–3, 2006, Hong Kong.

Malm R, Analys av sprickbildning och sprickbredd vid plant spänningstillstånd i balkliv av armerad betong, TRITA-BKN, Rapport 88, Brobyggnad 2005.

Malm R, Andersson A, Field testing and simulation of dynamic properties of a tied arch railway bridge, Engineering Structures 28(1), 143-152, January 2006.

Enckell M, Structural Health Monitoring using Modern Sensor Technology – Long-term Monitoring of the New Årsta Railway Bridge, Licentiate thesis, TRITA-BKN. Bulletin 86, Brobyggnad, 2006.

Enckell M and Wiberg J, Monitoring of the New Årsta Railway Bridge – Instrumentation and preliminary results from the construction phase, Teknisk rapport, Brobyggnad, 2005.

Andersson A, Gamla Årstabron, FEM-beräkning av förstärkningsåtgärders inverkan på betongbågarna, TRITA-BKN, Rapport 101, Brobyggnad, 2006.

Andersson A och Sundquist H, Gamla Årstabron, Utvärdering av verkningssätt hos betongvalv genom mätning och FEM-modellering – Etapp 1, Teknisk rapport 2005:13, Brobyggnad, 2005.

SB 3. A study of the dynamic interaction between train and bridge and the long-term changes in the dynamic properties of the new Årsta bridge

Researcher Raid Karoumi
 Johan Wiberg

The New Årsta Railway Bridge in Stockholm is a slender and a very complex prestressed concrete structure. Over 80 sensors, e.g. traditional strain gauge and fibre optic sensors, are embedded into the concrete section to monitor strains that arise from curing concrete, dead load, traffic, wind. The Swedish National Railway Administration (Banverket) initiated the measuring program to follow up stresses and deformations during construction and operation of the bridge. The dynamic and static behaviour of the bridge is investigated through inspection and supervision via internet connection to the sensors, which will give a unique opportunity for research on railway bridges and particularly the interaction between trains and the bridge.

The objective is to verify uncertainties in the structure, during construction and 10 years of service, leading to

knowledge and updated codes which, in turn, will give economical and safe solutions concerning similar structures in the future. The aim is to:

- Evaluate the fundamental frequencies, modes and damping ratios
- Evaluate the dynamic effects of trains crossing the bridge
- Evaluate the long-term changes in the bridge's dynamic properties.

Karoumi R, Wiberg J, Olofsson P: Monitoring traffic loads and traffic load effects on the New Arstabergr Railway Bridge. In: International Conference on Structural Engineering, Mechanics and Computation (SEMC 2004), Cape Town, South Africa, 2004.

Wiberg J, Bridge Monitoring to Allow for Reliable Dynamic FE Modelling: A Case Study of the New Årsta Railway Bridge, Licentiate thesis, TRITA-BKN. Bulletin 81, Brobyggnad, 2006.

Wiberg J, Karoumi R, Monitoring dynamic behaviour of a long-span railway bridge, accepted for publication in the journal Structures and Infrastructure Engineering.



SB 5. Sustainable bridges

Researchers

Håkan Sundquist
Raid Karoumi
Gerard James

The project is a European Community funded project that involves the cooperation between many partners from universities, railway infrastructure owners and industry around Europe and is part of the sixth framework programme.

The aim of the project is to produce guidelines and research papers to assist engineers in the evaluation of existing railway bridges. Much of the railway bridge stock in Europe is coming to an end of its originally planned service life, however, the demands on our railway bridges

are constantly increasing with railway operators requiring increased allowable axle loads and increased train speeds. There is a common European need to establish new and improve existing methods for the evaluation of this ageing railway bridge stock.

D4.2 Guideline for Load and Resistance Assessment of Existing European Railway Bridges. (under development)

James G, Karoumi R, Considerations for Traffic Loads in the Assessment of Existing Railway Bridges, IABMAS 2006, Porto, Portugal, July 16-19, 2006.

Jensen J S, Karoumi R, Melbourne C, Casas J R, Gylltoft K, Patrón A, Development of a Guideline for Load and Resistance Assessment of Existing European Railway Bridges, IABMAS 2006, Porto, Portugal, July 16-19, 2006.

SB 6. Soil-Structure Interaction for Integral Bridges and Culverts

Researchers

Håkan Sundquist
Esra Bayoglu

Bayoglu E, Karoumi R, Sundquist H, Field Testing of a Long-span Arch Steel Culvert during Backfilling and in Service, Structure & Infrastructure Engineering, Taylor & Francis, Vol. 1, No. 3, June 2005, pp. 181–188.

Bayoglu E, Field testing of a long-span arch steel culvert railway bridge over Skivarpsån, Sweden - Part III, TRITA-BKN Rapport 91, Brobyggnad 2005.

SB 7. Dynamic response of railway bridges subjected to high-speed trains

Researchers

Raid Karoumi
Johan Wiberg
Mahir Ülker

The project investigates the dynamic response of railway bridges on high-speed lines such as those for the new Bothnia line. The design speed for this line is for trains travelling at up to 300km/h. These types of speeds may cause excessively high stresses and vibrations, if the bridge is excited at one of its natural frequencies. Another problem to be studied is that of ballast instability where the downward accelerations of the bridge deck cause the ballast to lose its resistance properties to transverse forces.

Karoumi R, Wiberg J, Kontroll av Dynamiska Effekter av Passerande Tåg på Botniabanans Broar – Sammanfattning, TRITA-BKN Rapport 97, Brobyggnad, KTH, Stockholm, 2006.

James G, Karoumi R, Kullberg C, Trillkott S, Measuring the Dynamic Properties of Bridges on the Bothnia Line, TRITA-BKN Report 92, Brobyggnad, 2005.

Ülker M, Övervakning av accelerationer i broar vid passage av Gröna Tåget, Teknisk Rapport 2006:11, Brobyggnad, 2006.

SB 8. Bridge Weigh-in-motion for railway bridges

Researchers

Raid Karoumi
Axel Liljencrantz

The project aim is to develop, implement and test methods for weighing trains by means of instrumented bridges.

Liljencrantz A, Karoumi R, Twim – a MATLAB toolbox for real-time evaluation and monitoring of traffic loads on railway bridges, accepted for publication in the journal Structures and Infrastructure Engineering.

Liljencrantz A, Karoumi R, Olofsson P, Implementing Bridge Weigh-in-Motion for railway traffic, accepted for publication in the journal of Computers and Structures.

Liljencrantz A, Karoumi R, Olofsson P, Implementation of Bridge Weigh-in-Motion for Railway Traffic, ICWIM4, The Fourth International Conference on Weigh-In-Motion, Taipei, Taiwan, February, 2005.

Karoumi R, Wiberg J, Liljencrantz A, Monitoring traffic loads and dynamic effects using an instrumented railway bridge, Engineering Structures, Elsevier, No. 27, 2005, pp. 1813–1819.

O'Brien EJ, Quilligan M, Karoumi R, Calculating an Influence Line from Direct Measurements, J. Bridge Eng., Proc. Inst. Civil Eng., 159(1), March 2006, pp. 31–34.

SB 9. BRIDCAP – Increased load capacity of existing bridges on corridors

Researchers

Raid Karoumi

This is a project financed by the International Union of Railways (UIC). The project started in 2005 and ended in 2006. The project's main objective is to develop a guideline for railway bridge dynamic measurements and calculations in order to improve the use of existing railway bridges.

Guidelines for Railway Bridge Dynamic Measurements and Calculations, UIC leaflet, Union Internationale des Chemins de Fer, Version 1, January, 2006. (Edited by Karoumi R.)

Karoumi R, Simple bridge/vehicle models for studying the behaviour of bridges under dynamic traffic loads, In UIC seminar on Dynamic Effects of Railway Traffic on Bridges, Frankfurt, Germany, March, 2002.

Electric Power Engineering – EP

The laboratory for Electrical Machines and Power Electronics at the School of Electrical Engineering carries out research and education in the field of electric railway

traction. That includes traction motors, transformers, converters and electromechanical devices.

RESEARCH PROJECTS

EP1. New converter topologies for electric railway traction

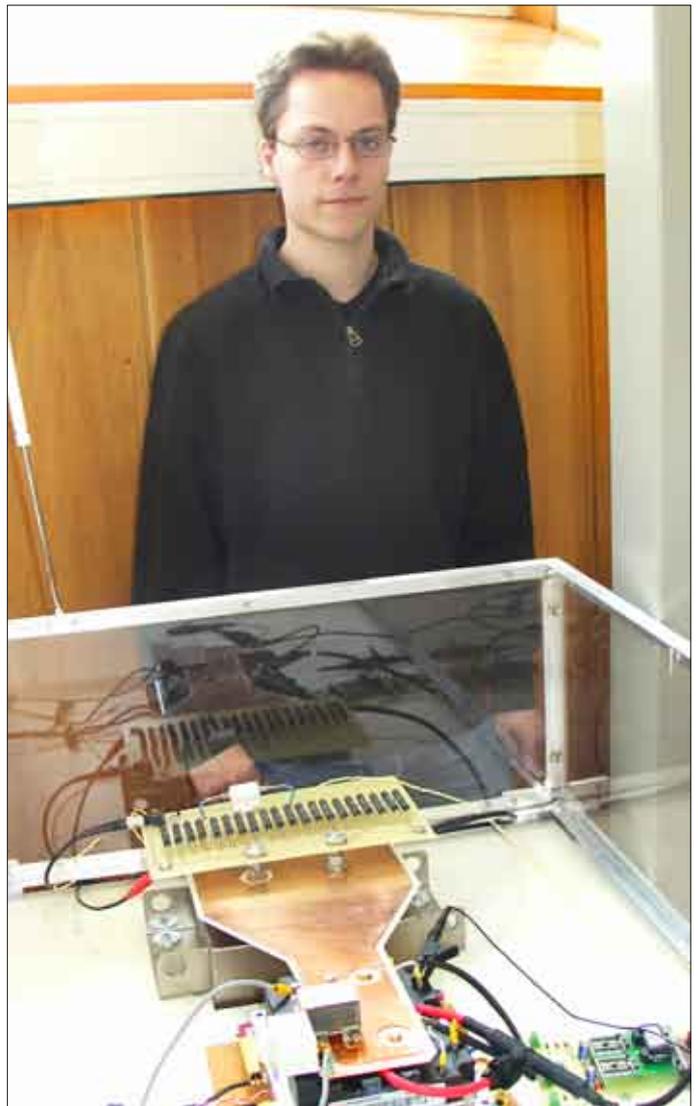
Researchers Stefan Östlund
 Staffan Norrga,
 Tommy Kjellqvist

Period: Stage 1 00-05, Stage 2 05-ongoing

Sources of funding: Banverket

PhD degree: Staffan Norrga "On Soft-Switching" Isolated AC/DC Converters without Auxiliary Circuit", May 2005

PhD degree: Tommy Kjellqvist "On Design of a Compact Primary Switched Conversion System for Electric Railway Propulsion". June 2009



Researcher PhD Tommy Kjellqvist



Prototype of medium frequency transformer for 200 kVA, 4 kHz.

The project is concerned with a new soft-switched medium frequency converter topology for rail vehicles. The proposed topology allows full four-quadrant operation and galvanic isolation by a transformer that can operate at arbitrary frequency.

All valves can operate under zero-voltage or zero-current conditions and the switching losses will be kept at a low level. This allows for high switching frequency which means that the transformer will be smaller and more efficient. The project consists of four parts, design of the transformer; characterization of soft-switched IGBTs for use in a snubbed VSC; Design of a high-voltage Cyclo-converter including gate-drives for series-connection of devices and finally system issues.

Kjellqvist T, Norrga S, Östlund S: *Switching Frequency Limit for Soft-Switching MF Transformer System for AC-fed Traction*. Proceedings the 36th IEEE Power Electronic Specialists Conference, Recife Brazil, 2005.

Norrga S: *Modulation Strategies for Mutually Commutated Isolated Three-Phase Converter Systems*. Proceedings the 36th IEEE Power Electronic Specialists Conference, Recife Brazil, 2005.

Kjellqvist T, Norrga S: *Harmonic Mitigation in Single Phase Mutually Commutated Converter Systems*. Proceedings the 37th IEEE Power Electronic Specialists Conference, Korea, 2006.

Kjellqvist T and Norrga S: *Active Snubber Circuit for Source Commutated Converters*, Proceedings of the EPE 2007 conference, Aalborg 2007

Norrga S: *Experimental Study of a Soft-Switched Isolated Bidirectional AC-DC Converter Without Auxiliary Circuit*, IEEE Transactions on Power Electronics, volume 21, 1580-1587, 2007

Kjellqvist T, Östlund S and Norrga S: *Active Snubber Circuit for Source Commutated Converters Utilizing the IGBT in the Linear Region*, IEEE Transactions on Power Electronics, volume 22, 2595-2601, 2008,

Kjellqvist T: *On Design of a Compact Primary Switched Conversion System for Electric Railway Propulsion*, PhD thesis Royal Institute of Technology, TRITA EE 2009:029, KTH, 2009

EP 2. Dual system locomotives for rail freight transportation/ Drive cycles for freight locomotives

Project leader Stefan Östlund Ph.D.
stefan.ostlund@ee.kth.se

Scientists Mattias Skoglund MSc
mattias.skoglund@tfk.se
Peter Bark, peter.bark@tfk.se

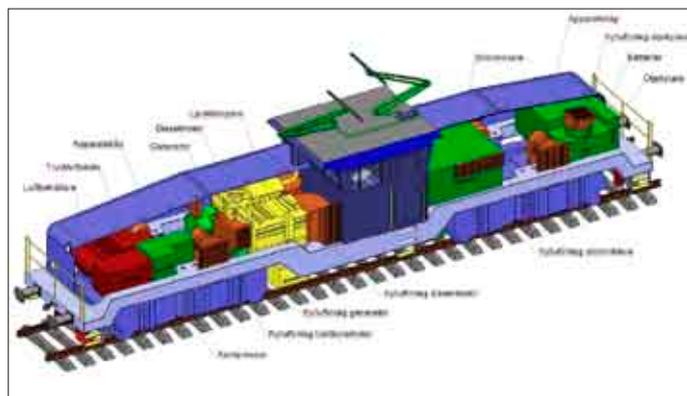
Source of funding: Banverket

Period: Stage 1 06-09, Stage 2 06 - ongoing.
The project is carried out in cooperation with TFK. It consist of two parts. The objective of the first part is to develop a specification for a dual-system freight locomotive. That is, a train with both a diesel engine and electrical supply. In the project has been studied both the

design of the locomotive an its impact on the operation regarding for instance energy consumption, logistics and emissions. The objective of the second part is to study drive cycles for freight locomotives. Better drive cycles are required for a more accurate evaluation of different locomotive concepts.

Skoglund M, Bark P and Östlund S: *Experiences from the Swedish T43H Hybrid Locomotive*, Nordiskt seminarium i Järnvägsteknik, Hook 22-23 maj 2008

Skoglund M, Bark P and Östlund S: *Dual mode locomotives – System studies of new freight locomotives for Sweden*, IEEE/ASME Joint Railroad Conference, April 2008



Dual system locomotive

EP3. System aspects of Permanent magnet traction motors

Project leader Juliette Soulard Ph.D.
juliette.soulard@ee.kth.se

Source of funding: Bombardier and Banverket
The project studies design aspects of permanent magnet traction motor drive including converter and gear as well as fundamental system issues for permanent magnet motor drives. The latter includes mechanical robustness and fault handling, e.g. short circuit of the motor and towing of a malfunctioning vehicle. The last phase of the project comprises a comprehensive evaluation of test runs.



Juliette Soulard, Project leader of EP3

EP 4. Train Information Management and Monitoring (TIMM)

Project leader Stefan Östlund Ph.D.
stefan.ostlund@ee.kth.se

Scientists

Source of funding: Vinnova

This is a two-year project (2006–2007) carried out by KTH and Swedish Institute of Computer Science (SICS).

Today the European railways are being deregulated and massive sums are invested in new infrastructure thus rail transportation is expected to increase considerably. The pressure on the railways to provide more flexible and efficient rail transportations makes it necessary to develop tools for common status information, deviation detection, prognoses, dynamic re-planning and optimisation. Such tools facilitate e.g. condition monitoring of vehicles and infrastructure via sensors in the vehicle or in the

infrastructure. The proposed project deals with the process of designing a platform for information management and monitoring of trains. The project consists of four work packages: WP1 Condition Monitoring, WP2 Diagnosis and deviation detection, WP3 Dynamic re-planning, WP4 Information platform issues. The work of the laboratory for electrical machines and power electronics is mainly within WP1 and deals with monitoring of the propulsion and in particular the current collection. Up to now the dynamics of train ride stability has been investigated.

Östlund S, Gustafsson A, Buhrkall L and Skoglund M: *Condition Monitoring of Pantograph Contact Strip*, 3rd Railway Condition Monitoring Conference, Derby UK, 2008

EP 5. Dynamic maintenance, Planning and Scheduling for Train Operation, DUST

Researcher Stefan Östlund
Mats Berg
Tommy Kjellqvist
Martin Bohlin SICS
Anders Holst SICS
Martin Aronsson SICS
Kivanc Doganay SICS

Source of funding: Vinnova, Euromaint Rail, Bombardier Transportation, Green Cargo

Period 2008–2011

The DUST project is a continuation of the TIMM project focusing on issues regarding Condition based maintenance in train operations, and its consequences for production planning and control. The focus is on how cooperation between different players can contribute to a more reliable and punctual operation through efficient and dynamic maintenance connected to planning and control.

The purpose is to develop methods that links the whole chain from condition monitoring to planned actions that is useful in real operation. That includes further development of methods for deviation detection, diagnosis, life-time analysis, dynamic re-planning and optimization, as well as assessing the methods in a common real scenario.



Machine Elements (Dept of Machine Design) – ME

KTH Machine design is performing research and education in the area of tribology of the wheel-rail contact. That includes the adhesion, wear and lubrication of the wheel-rail contact. In contrast to other well-investigated

machinery, such as roller bearings, the wheel-rail contact is an open system. It is exposed to dirt and particles and natural lubrication, such as high humidity, rain and leaves, all of which can seriously affect the contact conditions and

RESEARCH PROJECTS

ME1. Track-vehicle interaction (SAMBA6)–Wheel rail wear mechanisms and transitions

Project leader Ulf Olofsson
Graduate student Jon Sundh
Research engineer Peter Carlsson

Sources of funding: Banverket and KTH Railway Group
 An observation that can be made about wear is that an increase of the severity of loading at some stage leads to a sudden change in the wear rate. Wear transitions are identified using wear maps and are defined in terms of sliding velocity and contact pressure. Wear regimes are related to expected wheel rail contact conditions and contact points (tread/flange). Such wear assessments are becoming more significant as train speeds are increasing and new specifications are being imposed relating to safety and reliability. It can also help in determining more efficient maintenance schedules on particular routes; where different track profiles may be needed to reduce the severity of the wheel rail contact and where application of lubrication or change of material may be necessary to reduce wear problems. The transitions between the different wear mechanisms are studied with special emphasis on the transition between mild and severe wear. The test equipment to be used is a seizure tribometer

Tribology International, Vol. 41, Issues 9-10, (2008) 867-874.

Sundh J, Olofsson U, Olander L, and Jansson A., Wear rate testing in relation with airborne particles generated in a wheel-rail contact, Tribotest, vol 21 issue 4, p. 135-150.

Sundh J, and Olofsson U, Relating contact temperature and weartransitions in a wheel-rail contact, Presented on the 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2009), Firenze, Italy, September 15-18, 2009, Submitted to Wear.

Sundh J: An experimental study on wear transitions in the wheel rail contact, Licentiate thesis in machine Design, KTH, Stockholm, Sweden 2007.

Sundh J, Olofsson U, Olander L, and Jansson A: Wear rate testing in relation with airborne particles generated in a wheel-rail contact. Nortrib 08, June 2008, Tampere Finland, also submitted to Tribotest.

Sundh J, Olofsson U and Sundvall K: Seizure and wear rate testing of wheel/rail contact under lubricated conditions using a transient and a standard ball-on-disc test method, Wear, Vol. 265, Issues 9-10, (2008) 1425-1430.

Sundh J and Olofsson U: Seizure mechanisms of wheel/rail contacts under lubricated conditions using a transient ball-on-disc test method,



Project leader Professor Ulf Olofsson

ME 2. Adhesion between railway wheel and rail

Project leader Ulf Olofsson
Graduate student Zhu Yi
Research engineer Peter Carlsson

Sources of funding: Banverket and KTH Railway Group
The wheel rail contact operates with the limitations imposed by the friction existing between steel surfaces. Poor adhesion in braking is a safety issue as it leads to extended stopping distances. In traction, however, it is also a performance issue. If a train experiences poor adhesion when pulling away from a station and a delay is enforced the train operator will incur costs. Similar delays will occur if a train passes over areas of poor adhesion while in service. Fallen leaves can disrupt rail services all over Europe. A mature tree has between 10 000 and 50 000 leaves. There are estimations that thousands of tonnes of leaves fall onto railway lines every year. The leaves are usually swept onto the track by the slipstream of passing trains. While conditions leading to poor adhesion have been well investigated, methods for addressing the problems have not. The purpose of this project is firstly to develop a test method where friction modifiers can be evaluated in contact conditions and an environment that

correspond to the wheel rail contact. Secondly, the research aims to develop new environmentally friendly friction modifiers and, furthermore, to develop adhesion models for the railway wheel rail contact including contaminants.

- Olofsson U: Adhesion and friction modification, Wheel/rail interface handbook, ed. R. Lewis and U. Olofsson, Woodhead Publisher Limited 2009.
- Olofsson U: A multilayer model of low adhesion between railway wheel and rail, Proceeding of IMECHE part F, vol.221 (2007) 385-389.
- S.R. Lewis, U. Olofsson, R. Lewis, J. Cotter U., A study on top of rail friction. Influence of temperature, humidity, biological material and top rail modifiers. 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, Firenze, Italy, September 15-18, 2009.

ME 3. Airborne particles generated from train-track interaction

Project leader: Ulf Olofsson
Graduate student Saeed Abbasi
Research engineer Peter Carlsson

Source of funding: KTH Railway Group
A well known problem for the rail road industry is that the railway wheel and rail are worn. The profile change of rail on curves makes a large contribution to track maintenance cost. The profile change on wheels can also be significant, especially on a curved track. Another problem is that the material loss from the wheel, rail, brakes and pantograph generate airborne loose debris. Recent studies in underground systems and in stations placed in tunnels shows large numbers of airborne particles. The number and mass of airborne particles less than 10 µm usually exceed acceptable levels in the different countries and cities. There also exist EU guidelines for PM₁₀ (dir 96/62/EG), which often is exceeded (PM₁₀ refers to particles less than 10 microns, which are defined as small enough to enter into the alveoli of the human lung and be potentially dangerous). The purpose of this project is firstly to develop a test method where generated airborne particles can be evaluated in contact conditions and an environment

that correspond to the wheel rail contact. Furthermore, the project aims to develop simulations models for the generation of airborne particles from train track interaction with the aim to include them into simulation software's for train track interaction.

- Olofsson U: A study of airborne wear particles generated from the train traffic – block braking simulation in a pin-on-disc machine, 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2009), Firenze, Italy, September 15-18, 2009.
- Olofsson U, Olander L, Jansson A: Towards a model for the number of airborne particles generated from a sliding contact, Nordtrib 08, 11-13 June 2008 Tampere Finland, also Wear (2008), doi:10.1016/j.wear.2009.05.002

Transportation and Logistics – ToL

The group has special competence in the areas of traffic planning, customer preference evaluations, models for

explaining the number of passengers, capacity simulation models, logit models and travel time evaluations.

RESEARCH PROJECTS

FREIGHT AND LOGISTICS

ToL1. Model for supply and costs for freight transport by rail

Researchers Bo-Lennart Nelldal
Gerhard Troche

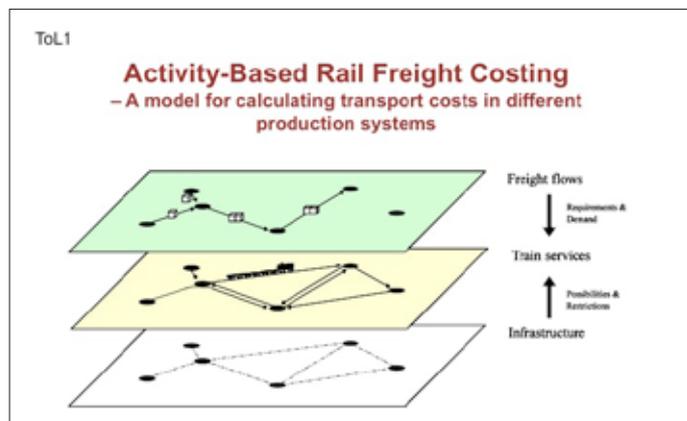
Sources of funding: Swedish National Rail Administration (Banverket) and Green Cargo (Swedish State Freight Railways) Duration: 1998-2008.

The aim of the project is to develop a supply model for production and cost structure of rail freight transportation. With the model it will be possible to predict the consequences of new railway production systems and changes in cost structure and obtain input data for forecasting models and calculations of new transport systems. The model is an activity based cost model (ABC) that also increase understanding of how costs are generated and of cost drivers.

With the model it will also be possible to calculate the effects of new transport systems and changes in performance in the railway system. Examples include

higher axle-loads, wider structural gauge, longer trains, automatic couplers and new traffic patterns. The model has among other things been used to evaluate new train concepts in the “Efficient train systems for rail freight transportation” project.

Activity-Based Rail Freight Costing – A model for calculating transport costs in different production systems, Doctoral Thesis, KTH Railway Group, TRITA-TEC-PHD 09-002. Gerhard Troche, 2009.



Researcher Professor Bo-Lennart Nelldal

ToL 2. Evaluation of intermodal transport chains

Researchers Bo-Lennart Nelldal
Sofia Lundberg
Gerhard Troche
Robert Sommar (KTH)
Ulf Carlsson (KTH-MWL)
Peter Andersson (Mariterm)
Peter Bark (TFK) et al.

Sources of funding: Swedish National Road Administration (Vägverket) and Swedish National Rail Administration (Banverket) through SiR-C (Swedish Intermodal Transport Research Center). Duration: 2006-2009.

Intermodal transport chains include several modes and terminal handling, which means specific costs and times and possible damage to the goods being transported. The aim of this project is to follow some intermodal chains and to investigate each link in the chain in respect of time, cost

and possible damage in order to find the weakest link in an intermodal transport chain that may be critical as regards more combined transports.

Different transport chains will be chosen with different modes, terminal handling and distances. Measurements can be made using instruments on a container, swap-body or trailer, that register time, temperature and vibration. The data will be stored and transmitted by cellular phone. The administrative process will also be investigated.

Evaluation of inter-modal transport chains. Bo-Lennart Nelldal, 2008. Conference proceedings at 7th European Congress on ITS, Geneva.

Evaluation of intermodal transport chains. Bo-Lennart Nelldal, Robert Sommar, Gerhard Troche. Conference proceedings at ITS New York 20 November 2008



ToL 3. Effects of distance-based road-user fees for trucks

Researchers Bo-Lennart Nelldal
Gerhard Troche (KTH)
Jakob Wajsman (Banverket)

Source of funding: Vinnova. Duration: 2005–2008.
Distance-based road-user fees for trucks have been introduced in some European countries and may also be introduced in Sweden. The aim of this project is to analyse how the fees will affect the modal split between road and rail transport. This will be done using both empirical data from Europe and forecasting models for Sweden. Different scenarios will be defined on the basis of the level of the fees and the road network in question and also in combination with stimulation for new transport by rail that also exists in some countries.

The result is expected to be the effect of distance-based road-user fees for trucks in Sweden on modal split. Different levels and systems for user-prices will be examined, which will provide better knowledge as a basis for political decisions.

Effekter av lastbilsavgifter – Analys av effekter av införande av avståndsbaserade lastbilsavgifter på konkurrens och samverkan mellan järnväg och lastbil. Forskningsrapport. TRITA-TEC-RR 09-02. Bo-Lennart Nelldal, Gerhard Troche och Jakob Wajsman, 2009.

ToL 4. Intermodal small-scale liner trains

Researchers Bo-Lennart Nelldal
Gerhard Troche (KTH)
Jakob Wajsman (Banverket)

Sources of funding: Swedish National Road Administration (Vägverket) and Swedish National Rail Administration (Banverket) by SiR-C (Swedish Intermodal Transport Research Center). Duration: 2008-2010.
Liner train systems with many small terminals can widen the market for inter-modal trains radically if the system is restricted to swap-bodies and containers of a maximum length of 10.7m and a weight of 25 tonnes. Ordinary cheap forklifts can then be used and the train can use many terminals on sidings along the way and containers can be lifted on and off during a 15 to 30-minute stop.

The aim of this project is to investigate the prerequisites for a demonstration project with a light-kombi system in Sweden (or between Sweden and another country) and then put the system into service and evaluate the demonstration project. The project includes market analysis integrated with Sir-C projects 1, 2 and 3, cost model calculations using KTH's model, and contacts with potential customers and operators.

ToL5. TESS – Intermodal Solutions for Trans European Temperature Sensitive Shipments

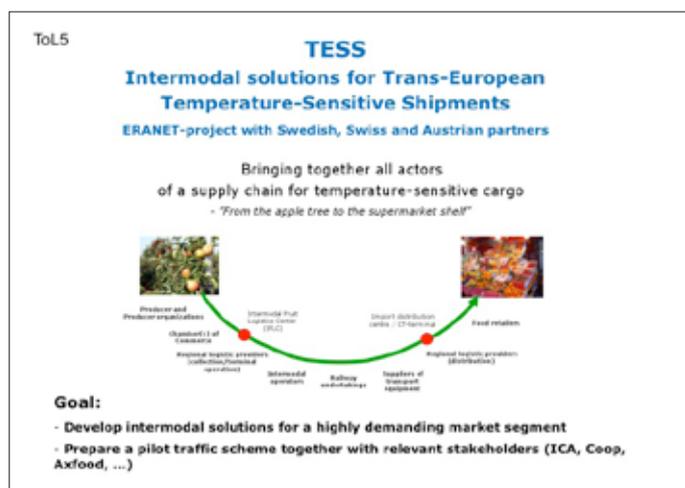
Researchers Gerhard Troche (KTH)
 Jonas Flodén (HGU)
 Tayssa Rytter (TfK Borlänge)
 Herwig Schöbel (Büro Herry, Wien)
 Philipp Schmidt (ETH Zürich)

The project, which began in 2008 and will end in 2010 is being conducted within the framework of the ERANET programme. The project is a collaboration between five parties from three countries: KTH Trafik & Logistik, the School of Business, Economics and Law at the University of Gothenburg and TFK Borlänge in Sweden, the consultancy firm HERRY in Vienna in Austria, and the Swiss Federal Institute of Technology Zurich in Switzerland. The project is funded by the public research agencies in the respective countries, in Sweden by the National Road and Rail Administrations through Sir-C (the Swedish Intermodal Transport Research Center).

The need to transport temperature-sensitive goods

– and food in particular – has increased markedly in recent decades. The railways have almost completely lost this market to trucks, especially in international traffic. The customers have adapted their logistics to road transport. Rising fuel prices, the introduction of road tolls, congestion problems on the motorways in central Europe, greater awareness of the impact on the climate from such transportation on the part of companies and, not least, consumers, have meant that the non-durables industry is once again demanding alternatives to today's transportation solutions.

The basic idea behind the TESS project is to bring players and their knowledge of the whole transportation chain together in order to develop a model case for international intermodal transport solution for temperature-controlled transport. The objective is to develop a transport solution in a pilot relation that will be able to be implemented in connection with the project.



ToL 6. MINT – Model and decision Support System for Evaluation of Intermodal Terminal Networks

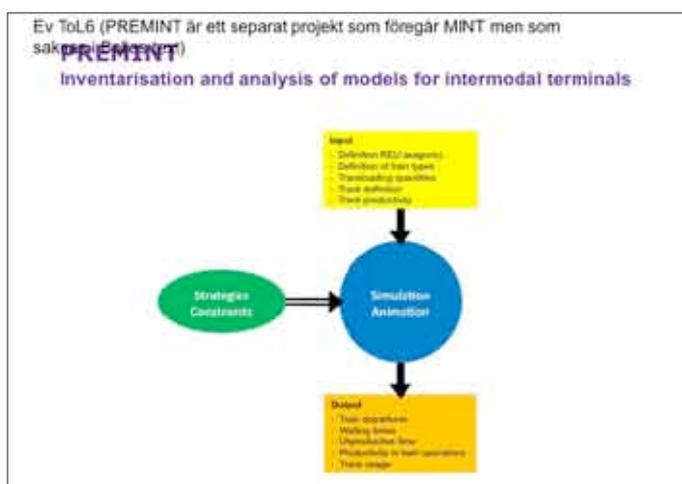
Researchers Gerhard Troche (KTH)
Fredrik Bärthel (TfK Borlänge)
Jonas Flodén (HGU)
Hans Häuslmeyer (BOKU, Wien)
Hans Rüsç (RAPP, Zürich)

The project, which began in 2008 and will end in 2010 is being conducted within the framework of the ERANET programme. The project is a collaboration between five parties from three countries: KTH Trafik & Logistik, the School of Business, Economics and Law at the University of Gothenburg and TfK Borlänge in Sweden, the University of Natural Resources and Applied Life Sciences, Vienna, Austria, and the consultancy firm RAPP Zürich in Switzerland. The project is funded by the public research agencies in the respective countries, in Sweden by the National Road and Rail Administrations through Sir-C (the Swedish Intermodal Transport Research Center).

The proposed project is a joint strategic and tactical

trans-national project researching a new, improved model and decision support system for evaluation of intermodal terminal networks – MINT. The result will be a model and decision support system of compatible and integrated models and methods to investigate, evaluate and analyse costs and benefits for terminal networks as well as single terminals.

The system is based on a number of models at different system levels and by combining the models some of their individual weaknesses are overcome. Together they form an excellent basis for improved system or terminal network design, investigation and evaluation. An information exchange structure will be developed to integrate the models. Finally an additional in-depth network analysis will complement the model's system to integrate other non-modelling aspects in the analysis. This model and decision support system will be the outcome of the MINT project



ToL 7. FTCS - Freight Transport Corridor Study

Researchers Sharin Nasir (KTH)

Source of funding: Malaysian Government. Duration: 2006–2010.

Malaysia container trade is expected to grow more than 60% between 2005 and 2020. 90% of local shipments to the hinterland are handled by road haulage and only 10% by rail freight. By looking at the dominance of road haulage, the opportunities for a modal shift from road to rail to improve container movement to the hinterland can be further explored. The government and the industrial players are looking at the idea of a modal shift from road to rail as one of the main solutions to reduce the pressure on roads and port congestion.

The main aim of the study is to analyze the factors that influence the development of rail freight services for container traffic from ports to the hinterland in a Malaysian perspective. This study will focus on container

movement from ports to the Malaysian hinterland. In developing a new service, the players involved in organizing and implementing the services must be identified.

The study will focus on the North Port as the main gateway to Malaysia and the Port of Göteborg as the comparison port. The Port of Göteborg has been successfully implementing a comprehensive rail freight service for container movement. 40% of its container movement to logistics centre in Sweden is through rail freight.

ToL 8. Other projects within SiR-C

Researchers Bo-Lennart Nelldal
Gerhard Troche (KTH)

Sources of funding: Swedish National Road Administration (Vägverket) and Swedish National Rail Administration (Banverket) by SiR-C (Swedish Intermodal Transport Research Center. Duration: 2006–2010. KTH Railway Group is participating in the virtual research center SiR-C (Swedish Intermodal Transport Research Center) together with Chalmers University of Technology (CTH), the School of Business Economics and Law at Gothenburg University (HGU), the Transport Research Institute (TFK), MariTerm, Transek-WSP and BMT Transport Solutions.

KTH is responsible for the project "Evaluation of intermodal transport chains" described above. KTH is also participating in the following studies as project leader: Strategic modelling of combined transport between road and rail (HGU), Intermodal transport of commodities (TFK) and Intermodal urban distribution – prospects and barriers (Transek-WSP). The last project deals with freight transport by tram and metro.

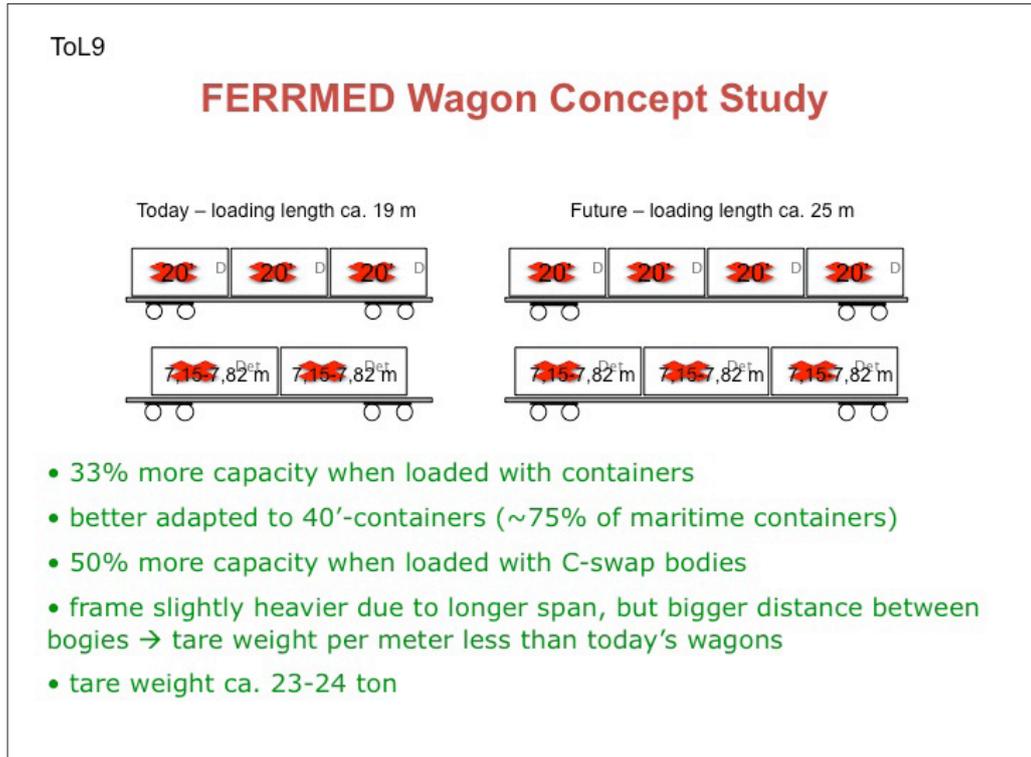
ToL9. New Opera and FERRMED

Researchers Bo-Lennart Nelldal
Gerhard Troche (KTH)

Sources of funding: EU. Duration: 2005–2009.
New OPERA and FERRMED are both EU projects that deal with future rail freight transport corridors in Europe. New OPERA stands for New European Wish: Operating Project for a European Rail Network and is a coordinated effort in the area of joint European railway research. New OPERA will study the necessary changes to achieve a long-term scenario by 2020 of a core network

predominantly dedicated to rail freight. FERRMED is a private organisation to promote a freight railways axis in Scandinavia-Rhine-Rohne-Western Mediterranean. Bo-Lennart Nelldal is a member of the scientific committee of the New OPERA project and Gerhard Troche is a member of the advisory board of FERRMED.

New OPERA was concluded in 2008 with the report “New Opera – The Rail Freight Dedicated Lines Concept”, edited by Franco Castagnetti.



ToL10. Gröna tåget – market and services

Researchers Oskar Fröidh
Bo-Lennart Nelldal
Johannes Wolfmaier
Hans Sipilä

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2005–2009 (2011).

The aim of the research Gröna Tåget (Green Train) programme, www.gronataget.se, is to strengthen Swedish competence in developing and procuring the future generation of high-speed trains according to Swedish requirements and special conditions. The aim is also to strengthen possibilities to participate in and influence the all-European programme of railway research and standardisation.

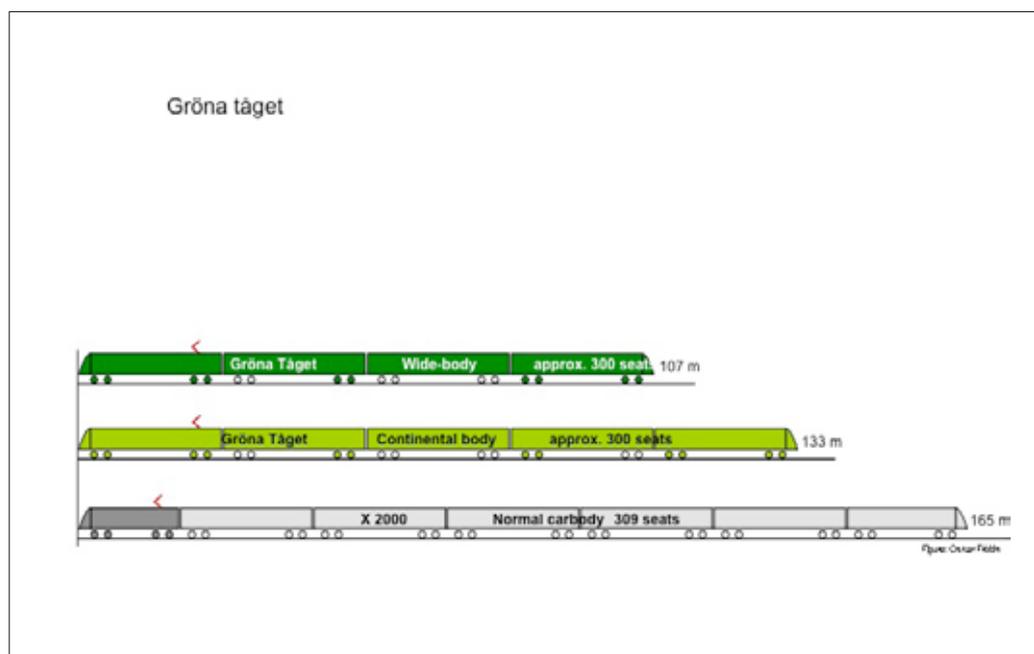
Market and services for the Gröna Tåget will be a frame for many technical and economic issues. One important task is to set a platform for an internationally viable

knowledge base of train concept design. The market and services section has the aim of designing a concept for the new train with high customer values, i.e. identify new market segments for services and to work out a suitable performance specification and layout with respect to customer valuations and travel demand.

An important factor is to examine customers' demand for shorter travelling times and make simulations for different specifications of vehicles and track parameters to try to find an optimum. This will be made by different top speed and tractive effort, with or without tilting, different track layout and different stopping patterns.

Fröidh, Oskar (2008): Perspectives for a future high-speed train in the Swedish domestic travel market. *Journal of Transport Geography* 16, 268-277

Sipilä, Hans (2008): Körtidsberäkningar för Gröna tåget. KTH Järnvägsgruppen publikation 0802



Researcher Ph D Oskar Fröidh

ToL 11. High-Speed Trains in Sweden – Supply and demand

Researchers Bo-Lennart Nelldal
Oskar Fröidh
Gerhard Troche.

Several specially commissioned studies have been made over the years of a future high-speed network in Sweden, the “European Corridor”. The idea is to build special high-speed lines for speeds of up to 300-350 km/h on the Stockholm-Linköping-Jönköping route and from there to both Göteborg and Helsingborg-Malmö/Copenhagen. From there the trains can continue on to Hamburg via the planned fixed link to the Fehmarn Belt. This will make it possible to travel from Stockholm to Linköping in 1 hour, to Göteborg in 2, to Malmö in 2:30, to Copenhagen in 2:50 and to Hamburg in less than five hours. At the same time capacity is freed on the old main lines for freight trains and regional trains.

The first analyses were made at the assignment of the European Corridor between 2001 and 2003 when market and supply as regards a future high-speed network were analysed and forecasts and socioeconomic calculations made. Since rail traffic has increased substantially in recent years and the need for more capacity has become increasingly apparent, the question of building high-speed lines has arisen and several studies were conducted during 2008. Banverket (the National Rail Administration) was commissioned by the Government to investigate the prerequisites for high-speed lines in Sweden and they in turn commissioned KTH to draw up a report on the prerequisites that formed the basis for Banverket’s decision in favour of high-speed trains.

A group of stakeholders – SJ AB, Green Cargo, Alstom, Jernhusen and the Nordic Investment Bank – funded a business analysis that also presented a funding and implementation model for high-speed lines, “Nya tåg i Sverige” (New Trains in Sweden). KTH also participated in this, contributing forecasts and socioeconomic calculations. In 2008 KTH also published a special study

commissioned by the European Corridor of the effects of high-speed lines on freight traffic. The findings of KTH’s only externally funded research project on high-speed trains were also published in 2008, see below. In autumn 2008 the Government commissioned a special study of high-speed trains due to be completed in autumn 2009 where KTH is also participating with supporting material.

These projects have been especially important for KTH since they have also contributed to the construction of new forecasting models for passenger traffic. The conventional forecasting models, in Sweden the national forecasting system Sampers, are unable to reflect the effects of the large system changes that high-speed trains lead to. A new forecasting system, Samvips, has been developed by KTH in collaboration with ÅF and socioeconomic analyses have been linked to it. Compared to international experience of high-speed trains, this system produces realistic results. However, the need to further develop the national forecasting systems and calculations still remains and for this a special research model would be required.

Nelldal, B.-L.; Troche, G.; 2001. Europakorridoren – Ett bredband för fysiska transporter. Rapport från KTH 2001-08.

Nelldal, B.-L.; Troche, G.; Jansson, K. 2003. Europakorridoren – Utbud, prognoser och samhällsekonomi. Rapport från KTH, Stockholm.

Nelldal, B.-L., Lindfeldt, O., Troche G.; 2008. Godstrafikens möjligheter som en följd av en satsning på Europakorridoren. Rapport. KTH, Stockholm 2008-09-08.

Nelldal, B.-L.; 2008. Höghastighetsbanor i Sverige – Götalandsbanan och Europabanan. Rapport för Banverket. KTH, Stockholm 2008-05-30.

Nelldal, B.-L., Fröidh, O., Lindfeldt, O., Troche G.; 2008. Nya tåg i Sverige: Marknad, trafik och prognoser. Underlagsrapport till Railize. 2008-08-19.

ToL 12. High-Speed Trains – a business approach and benefit to society

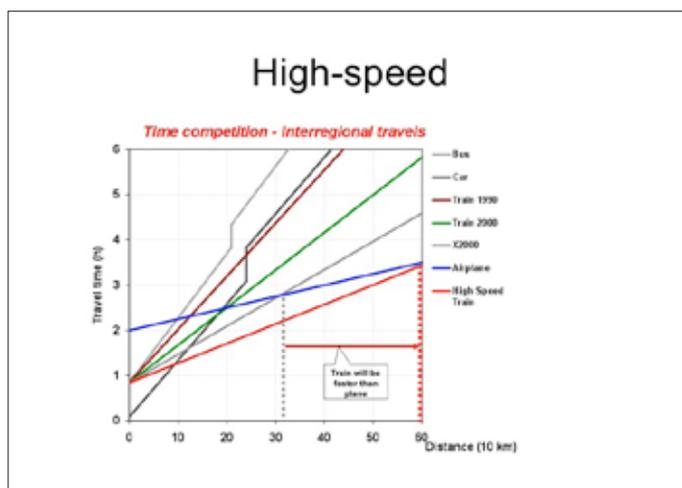
Researchers Bo-Lennart Nelldal
Oskar Fröidh (KTH)
from Transek AB/WSP:
Sara Björlin-Lidén
Bodil Sandén
Elisabet Idar Angelov
Göran Tegnér
Cristian Nilsson

Sources of funding: Vinnova and Alstom Transport AB.
Duration: 2006-2008

The aim is to gain increased knowledge of the contribution of high-speed trains to sustainable development. The task is to investigate what speed standard, types of trains, service quality and time for development that a future high speed network requires from a socio-economic and a private operators' perspective. The work will be organised into five subprojects: optimal speed strategy, train types and system solutions, user driven service quality, profitability, and socio-economic efficiency.

For potential high-speed lines the speed standard will be varied systematically. The analyses show how demand, market shares, operators' surplus and socio-economic efficiency vary with different levels of service. In the subproject "user driven service quality", a method is being developed for using customers' demand in the development of innovative services. The analyses will be carried out for different parts of the railway network and for complete networks.

Björlin-Lidén, S., Idar Angelov, E., Nilsson, C., Sandén, B., Nelldal, B.-L., Fröidh, O. (2008): Höghastighetståg – affärsmässighet och samhällsnytta. Forskningsrapport WSP och KTH



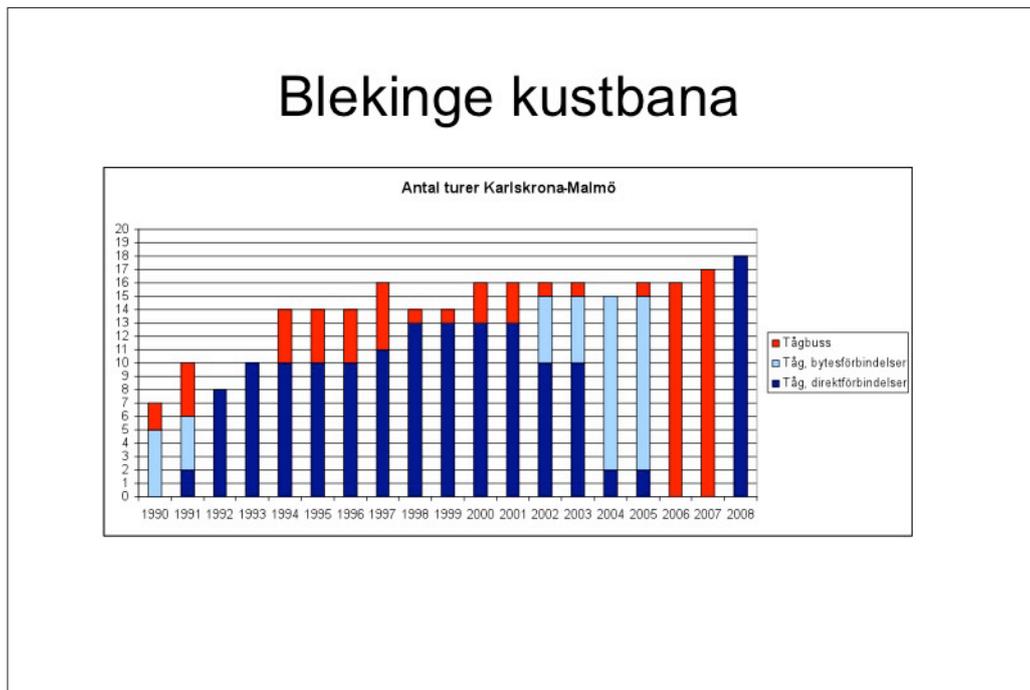
ToL 13. Follow-up of travel demand along the Blekinge Coast line at supply changes

Researchers Oskar Fröidh
Karl Kottenhoff

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2006–2009.

The Blekinge Coast line between Karlskrona and Kristianstad in southern Sweden will have direct services to Malmö when the now ongoing electrification is completed in 2007. During the electrification work, the trains are replaced by comfortable buses, which in turn replaced the Kustpilen DMUs.

The research project will be carried out as a case study of the Blekinge Coast line before and after the introduction of electrical regional trains. The scope is interviews with travellers including RP and SP, and also collection and analyses of bus and train supply and travel demand data. The results will be connected to a forecast model in case of large supply changes. A final report will be published in 2009.



ToL 14. Car ownership model considering accessibility and public transport supply

Researchers Bo-Lennart Nelldal
Oskar Fröidh
Staffan Algiers (Transek AB/WSP)
from the consultant Transek AB as well as
Isak Jarlebring and Joakim Köhler

KTH and Transek concluded a research project funded by the Swedish National Rail Administration in 2005. In 2006 an application was submitted to continue developing the model into a fully tested and implemented part of the national forecasting system SAMPERS.

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2003–2008.

Access to a car is an important factor when considering choice of mode for travelling. In the national forecast system, SAMPERS, an older car ownership model was implemented, which has proved to be inaccurate, in particular as regards urban areas with a good public transport supply. This project aims to develop a new car ownership model based on accessibility measures and with respect to the public transport supply for different regional structures.

ToL 15. Public transport worth its price – effects on regional commuting

Researchers Karl Kottenhoff
Oskar Fröidh (KTH)
Kjell Jansson (KTH/ÅF)
From the consultant ÅF also
Chris Halldin

Source of funding: Vinnova. Duration: 2004-2007.

The aim of the project is to show how reduced generalised travel costs for public transport contribute to enlarging the regional labour market in the Stockholm and Mälardalen regions. The following goals are important: a higher employment rate, greater competence provision and lower social costs. Means to reach these goals include: Reducing travelling times, increasing and levelling out travelling comfort for trips across the county border, and adjusting the price structure to reduce great cost differences.

These measures increase accessibility to public transport and can reduce car traffic. In this way, economic growth and environmental sustainability can be promoted.

The results are presented as generalised costs, regional distribution, accessibility, financial effects, externalities,

social economics, social distribution effects, and potential for growth. Moreover, more specific issues have come to light, for example the value being able to work while commuting. The project consists of four studies:

- A study of passenger valuations of comfort and a proposal for a new standard.
- A study of the possibilities to improve the supply of public transport services.
- An analysis of alternative fare structures.
- A simulation of improved public transport resulting in socioeconomic valuations.

Fröidh, Oskar, Jansson, Kjell, Kottenhoff, Karl (2007): Kollektivtrafik värd priset för integrerad arbetsmarknad, fallstudie Mälardalen

TRITA-TEC-RR 07-006

ToL 16. Monetary valuation of ride comfort related to track quality

Researchers Karl Kottenhoff
Jerker Sundström
Birgitta Thorslund (VTI)
Camilla Byström (Transek AB)

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2001–2007.

The purpose of this study is to quantify train passengers' ride comfort with respect to track maintenance.

How much are passengers willing to pay for a higher standard? The project consists of two parts. The first is a perception study that will show how passengers perceive train comfort. In the second study, the train

passengers' willingness to pay for maintained comfort will be estimated. The project is being conducted in a joint collaborative effort between KTH, VTI and Transek AB.

Förstberg J, Kottenhoff K, Olsson C, Visst skakar det – men är resenären beredd att betala för högre åkkomfort? Slutrapport från projektet Monetära åkkomfortvärderingar, februari 2005, TRITA-INFRA-05-007

Jerker Sundström, Karl Kottenhoff och Camilla Byström : Visst skakar det - men är tågresenären beredd att betala för högre åkkomfort? Tillägg om lokala spårlägesfel (tillägg till slutrapporten 05-007) TRITA-TEC-RR 07-008, 2007

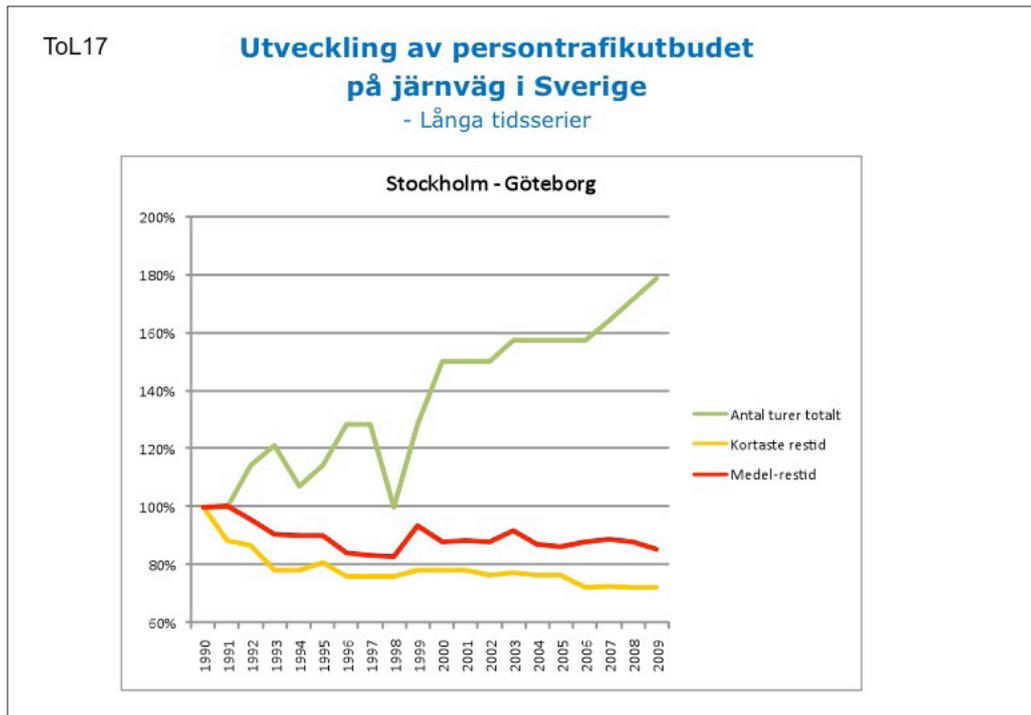
ToL17. Database of supply and prices for railway lines in Sweden

On behalf of Banverket the department of Transportation and Logistics has continuously built up a database of supply and prices for 56 railway lines in Sweden. The database now consists of the years 1990-2008 and will be updated every year. The content is facts about travel times, frequencies and prices for relations for different products (i.e. high-speed, InterCity, and commuter trains) for SJ traffic, regional authorities' traffic, state subsidized traffic, and private traffic. A report will be published every year that will also include some special analyses made for Banverket's annual report "Swedish Rail Sector".

Nelldal B-L, Troche G, Utveckling av utbud och priser på järnvägslinjer i Sverige 1990-2005 samt utvecklingen av flyg- och busskonkurrens 2005. TRITA-TEC-RR 06-001, 2006

Nelldal B-L, Troche G, Utveckling av utbud och priser på järnvägslinjer i Sverige 1990-2006 samt utvecklingen av trafiken i storstadsområdena. KTH 2007, not printed.

Nelldal B-L, Troche G, Utveckling av utbud och priser på järnvägslinjer i Sverige 1990-2007 samt utvecklingen av storregionala trafiksystem och konkurrensen tåg-flyg. KTH 2008, not printed.



ToL18. Other projects, papers and reports

Oskar Fröidh och Olov Lindfeldt, 2008; Svealandsbanans första 10 år - erfarenheter för framtiden av tågtrafiken och resandet. TRITA-TEC-RR 08-002. Rapport utarbetad på uppdrag av Svealandsbanans intressenter.

Bo-Lennart Nelldal: Möjligheter för tåget att konkurrera med och ersätta flyget. Rapport utarbetad på uppdrag av Banverket 2007 (pdf).

Oskar Fröidh and Bo-Lennart Nelldal: Regional high-speed trains on

the Svealand line: Evaluation of effects. 2008. Chapter in Bruinsma, F., Pels, E., Priemus, H., Rietveld, P., van Wee, B. (eds.): Railway development. Impacts on urban dynamics, 295-314. Physica-Verlag, Heidelberg

ToL19. Future infrastructure and train run quality

Researchers Bo-Lennart Nelldal
 Olov Lindfeldt

Source of funding: Swedish National Rail Administration (Banverket)

Duration: 2004-2009.

This project has two major parts: capacity design of single-track railways and capacity design of double-track railways. Punctuality, i.e. delay distributions and train run quality, are important factors in both parts. The two parts together will form a PhD thesis.

For single-track railways two different types of infrastructure are analysed: Single-track with short twin-track sections in order to obtain time-efficient and robust crossings, and single-track with ordinary crossing stations only.

These infrastructure options are analysed with analytical (statistical) methods and with simulations in RailSys. A comparison is made in respect of overall capacity, travelling times and robustness.

Olov Lindfeldt: Quality on single-track railway lines with passenger traffic - Analytical model for evaluation of crossing stations and partial double-tracks. Licentiatavhandling. TRITA-TEC-LIC 07-003, 2007.

Olov Lindfeldt: Effekter av partiella dubbelspår och fler mötesstationer på enkelspår TRITA-TEC-RR 07-009, 2007.

Olov Lindfeldt : SAMFOST - a Timetable-free way of Analysing Single-track Railway Lines. 2007. Conference proceedings to 2nd International Seminar on Railway Operations Modelling and Analysis, Hannover.

Olov Lindfeldt: Influences of station length and inter-station distance on delays and delay propagation on single-track lines, In: Allan J, Brebbia C A, Rumsey A F, Sciutto G, Sone S, Goodman C J (eds.), / Computers in Railways X/, pp. 511-520, WIT Press, Southampton, 2006.

ToL 20. Congested infrastructure

Researcher Anders Lindfeldt

Source of funding: Swedish National Rail Administration (Banverket)

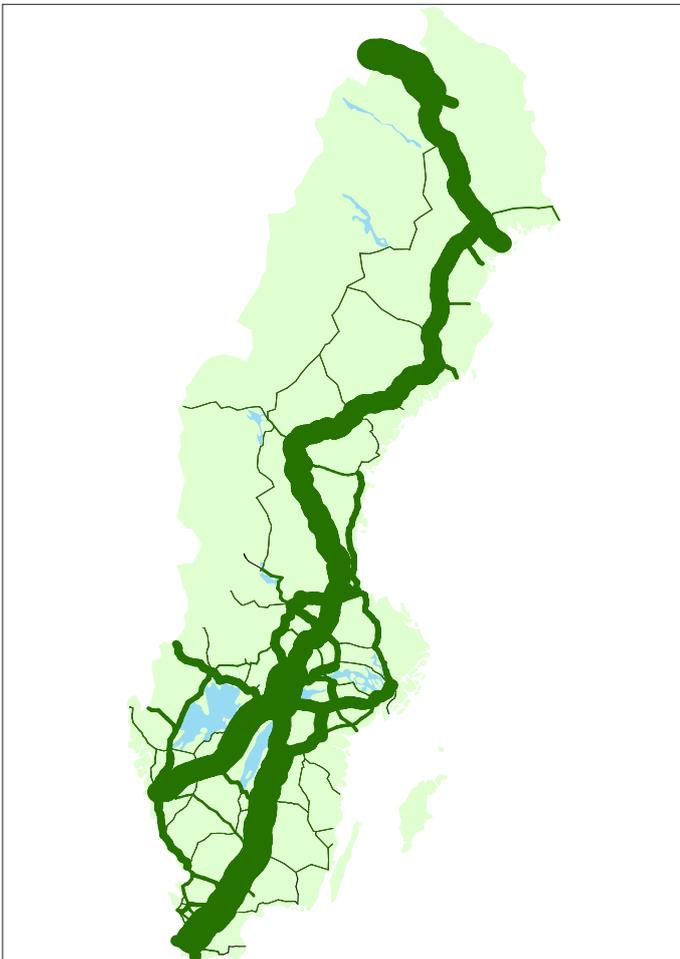
Duration: 2008-2010.

The load on the Swedish rail network is increasing and Banverket (the National Rail Administration) has officially declared parts of the network to be overloaded. The purpose of the project is to determine the capacity limits for rail traffic under different conditions. One approach is to analyse how the load on the rail network affects the risk of delay, another to try to find a “volume delay” function for train traffic, i.e. the point where the infrastructure becomes so loaded that delays increase and cause capacity to fall. In this way it is possible to determine the limits for a robust timetable under different conditions.

First, a database was created of Sweden’s rail network containing data of the infrastructure, the numbers of trains, the timetables and the delays. A general analysis is being made of capacity utilisation on different railway lines in Sweden in order to find linkages between different variables and determine the capacity limit under different conditions. The analysis is being made in respect of both single- and double-track lines with different kinds of traffic.

The next step is to construct an analytical model of a real station with several connecting lines. The model will be used to analyse how resulting delays are affected by different initial delays and choice of timetable structure etc. A large number of simulations will then be made in a simulation tool. The results of the simulations will be validated against real delay figures and compared with the results from the analytical model.

The results will among other things be able to be used to calculate how many trains can be permitted without punctuality falling below a certain level, given a certain type of initial delay.



ToL 21. Timetable planning with simulation

Researcher Hans Sipilä

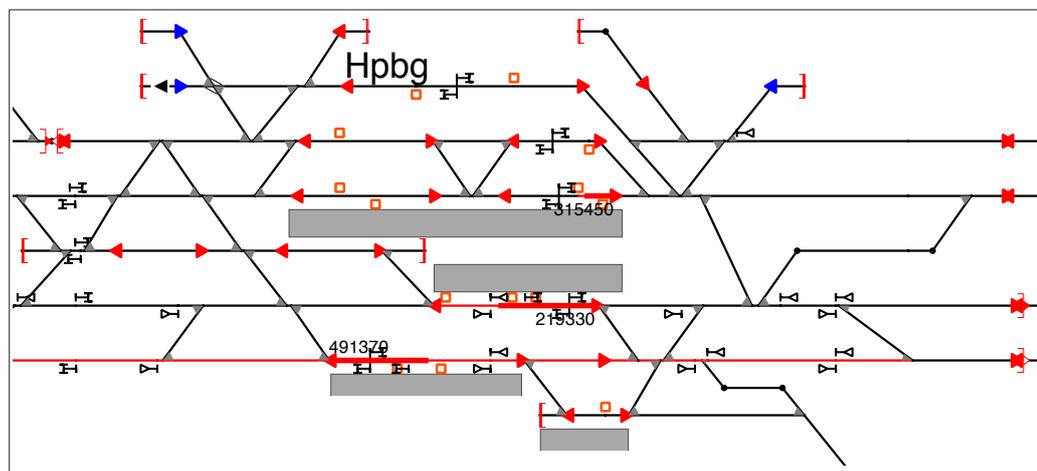
Source of funding: Swedish National Rail Administration (Banverket)

Duration: 2008-2010.

As rail traffic increases, the infrastructure comes under increasing pressure and as a result of deregulation more actors are appearing on the scene, which increases complexity at the same time as demands are growing for more flexibility in the timetables. The purpose of this project is to analyse whether it is possible to improve timetable planning by drawing up the timetables with the help of simulation. The aim is to study whether it is possible in the long term to accelerate the planning process and improve the quality of the timetables by being able to simulate the effects of different proposed timetables in advance.

The project also aims to try to design timetables that will improve punctuality for the X2000 trains. The effects of both minor adjustments by extending time and adding margins between the trains in today's timetable and larger structural changes in the traffic design that can be made over a longer period will be studied. The intention is also to create simple, usable guidelines for timetable planning.

The project is run alongside the timetable planning process one year at a time for the western main line Stockholm-Göteborg, the southern main line Stockholm-Malmö and the east coast line Stockholm-Sundsvall. A researcher at KTH and planners from SJ and Banverket work in parallel on timetable construction and simulation. It is being conducted as a doctoral project where the outcome of the planning is also followed up.



ToL 22. Simulation and capacity analysis

Through its cooperation with IVE (The Institute of Transport, Railway Construction and Operation) at the University of Hannover, KTH has access to the Railsys simulation model, which has been developed with great effort over many years and is in use today in many countries around the world. Railsys is handled commercially by RMCon (Rail Management Consultants). In the simulation model the infrastructure is defined with all tracks and signalling blocks as well as the timetable and the vehicles (trains). The result shows how a given line and timetable will handle various events, e.g. delays.

In 2006 Banverket chose Railsys for their future work. The Railway Group is also a sub-contractor of Railsys

in Sweden and offers support and education in Railsys in Sweden. A user group will be formed to exchange experience.

The Railway Group also offers commissioned capacity analyses and simulations. Simulations have been carried out of the following railway lines: "Ostlänken" Stockholm-Linköping, "Svealandsbanan" Stockholm-Eskilstuna, "Nynäsbanan" Västerhaninge-Nynäshamn, and "Västra stambanan" Stockholm-Järna.

Bo-Lennart Nelldal, Olov Lindfeldt, Hans Sipilä och Johannes Wolfmaier: Förbättrad punktlighet på X2000 - analys med hjälp av simulering Uppdragsrapport TRITA-TEC-RR 08-001, 2008



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