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KTH Railway Group

Status Report 2013

Instrumentation of bridge across Söderström for long time monitoring with accelerometers and strain gauges.

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Cover photo: Botnia line, test run with Gröna Tåget

RV RAIL VEHICLES	RV RAIL VEHICLES	RV RAIL VEHICLES	SB STRUCTURAL ENGINEERING 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	RV21 Wheel profile for freight wagons in Sweden	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	RV22 Modelling contact in the wheel-rail interface	SB5 Sustainable bridges
RV5 Dynamic instability and discomfort of high-speed trains due to aerodynamics in tunnels	RV14 Gröna Tåget – Energy consumption	RV23 Make Rail The Hope for protecting Nature (MARATHON)	SB6 Soil-Structure Interaction for Integral Bridges and Culverts
RV6 Robust safety systems of trains	RV15 Gröna Tåget – Active lateral suspension	RV24 The sustainable freight railway (SUSTRAIL)	SB7 Dynamic response of railway bridges subjected to high-speed trains
RV7 Simulation of energy consumption and running time of trains	RV16 Gröna Tåget – Overhead power systems for operation of high-speed trains in Sweden	RV25 Planning tool for energy-saving loading strategy for intermodal freight trains	SB8 Bridge Weigh-in-motion for railway bridges
RV8 Train formation management and monitoring (TIMM)	RV17 Collaboration in research and development of new curriculum in sound and vibration (CIRCIS)		SB9 BRIDCAP – Increased load capacity of existing bridges on corridors
RV9 Crosswind stability and unsteady aerodynamics in vehicle design	RV18 Railway vehicle dynamics and track interactions: Total regulatory acceptance for the interoperable network (dynoTRAIN)	GREY BOXES INDICATE TERMINATED PROJECTS	SB10 Enhanced Fatigue Evaluation of Old Steel Railway Bridges

SB	EP	ME	ToL
STRUCTURAL ENGINEERING AND BRIDGES	ELECTRIC POWER ENGINEERING	MACHINE ELEMENTS (DEPT OF MACHINE DESIGN)	TRAFFIC AND LOGISTICS
SB 11 Development and Implementation of Monitoring Systems for Increased Safety and Improved Operation and Maintenance of Railway Bridges	EP 1 New converter topologies for electric railway traction	ME 1 Track-vehicle interaction (SAMBA 6) – Wheel rail wear mechanisms and transitions	ToL 1 Model for supply and costs for freight transport by rail
SB 12 Development of Methodology for LCC and LCA of Railway Bridges	EP 2 Dual system locomotives for rail freight transportation/ Drive cycles for freight locomotives	ME 2 Adhesion between railway wheel and rail	ToL 2 Regional Intermodal Transport Systems – Analysis and Case Study
SB 13 Efficient Assessment Methods of the Dynamic Response of Existing Railway Bridges to High-speed Trains	EP 3 System aspects of Permanent magnet traction motors	ME 3 Airborne particles generated from train-track interaction	ToL 3 Efficient feeder transports by rail
SB 14 Train-track interaction	EP 4 Train information Management and Monitoring (TIMM)	ME 4 Block brakes during winter conditions	ToL 4 SCANDRIA – Scandinavian-Adriatic Corridor for Growth and Innovation
	EP 5 Dynamic maintenance, Planning and Scheduling for Train Operation, DUST	ME 5 Quit track	ToL 5 Bothnian Green Logistic Corridor (BGLC)
	EP 6 Railway Power Supplies with new converter and system topologies		ToL 6 COINCO north –Border problems for rail transportation
			ToL 7 The VEL wagon – efficient and longer wagons for future freight transportation
			ToL 8 TRANSFORUM – Possibilities to realise the goals in the EU's White Paper
	GREY BOXES INDICATE TERMINATED PROJECTS		ToL 9 Major traffic interruptions on Sweden's railways 2000–2013 and their impact for customers

ToL TRAFFIC AND LOGISTICS	ToL TRAFFIC AND LOGISTICS	MW MARCUS WALLENBERG LABORATORY FOR SOUND AND VIBRATION RESEARCH
ToL 10 Efficient freight traffic – high and narrow loading gauge	ToL 19 Future maintenance and depots – research program	MW1 Gröna Tåget – noise and vibration part
ToL 11 Future freight transportation in the Eastern Sweden Region 2010-2030-2050	ToL 20 Congested infrastructure	
ToL 12 Green Freight Train – Roadmap for rail and intermodal freight transportation	ToL 21 Timetable planning with simulation	
ToL 13 Gröna tåget with active lateral suspension – evaluation of comfort	ToL 22 Development of time table strategies	
ToL 14 High-Speed Trains in Sweden – Supply and demand	ToL 23 Freight traffic by rail – measurements for increased capacity	
ToL 15 HSLdim – Optimal speed for new high-speed railways	ToL 24 Analyse of capacity and punctuality 2008–2012	
ToL 16 Development of forecast models – Forecast model based on scenarios	ToL 25 Analysis of time-tables, delays and capacity utilization by KAJT	
ToL 17 Database of supply and prices for railway-lines in Sweden	ToL 26 Analysis of track access charges and the rail market	
ToL 18 Evaluation of the deregulation and competition in long distance traffic in Sweden	ToL 27 Program for research and innovation in signalling systems	

GREY BOXES INDICATE TERMINATED PROJECTS

KTH Railway Group in 2013

In May 2013 KTH Railway Group celebrated its 25th anniversary with a well-attended seminar and a glass of champagne. The Railway Group was formed in 1988 as an informal organization to support and coordinate expertise in the area of railway technology at KTH. Since 1996, the Railway Group is a formal research and development centre in rail technology at KTH. The main tasks are research, higher education at undergraduate, graduate and postgraduate level, and training for employees in the railway field. The funding is today regulated by an agreement between KTH, the Swedish Transport Administration (Trafikverket), Bombardier Transportation, Stockholm Public Transport (SLL), the Swedish State Railways (SJ) and the consultant companies Interfleet Technology and Vectura. In the beginning of 2013 a four-year agreement lasting until the end of 2016 was signed.

The seminar mentioned above mirrored the challenges the railways have to face in the coming years – both in Sweden and the rest of the world. After a short historical background about the work of KTH Railway Group in the past Ole Kjörrefjord, chairman of the board of Hector Rail, talked about the consequences of deregulation. Nowadays it is possible with competition also in passenger traffic on Swedish mainlines. He foresees new palmy days for railways in the future. There are, however, a lot of hurdles to take before we are there. Many of the hurdles were discussed in the presentation after by a number of researchers active in the Railway Group. More competition on railways means hopefully more traffic. How can this be accommodated on already congested and in many cases not well maintained infrastructure? Also energy supply in and near the biggest cities can sometimes become a problem when traffic increases. Solutions to these capacity issues have been and will be an important direction of our research. Other issues will be how to maintain existing infrastructure and how to build new infrastructure at affordable costs. Money will always be a scarce resource.

On a competitive railway market only companies with a clear customer focus survive. One of the most important issues here is reliability. Both in passenger and in freight traffic the operators need to keep what they promise. The ability to achieve this of course includes the whole system, including infrastructure. Ole Kjörrefjord says that some freight customers do not dare to choose rail transport today even though it is cheaper because they do not trust the reliability.

In the future we will see competition also on fast passenger traffic in Sweden. This means that passenger comfort will become even more important. KTH Railway Group has a long tradition on running gear development both regarding track friendliness and ride comfort. In May 2013 on track tests with an active vertical suspension on Gröna Tåget were carried out. The results indicate a comfort improvement with 20%-30% compared to the passive solution, a very encouraging result.

Railway traffic is regarded as environmentally friendly. This is of course true, but we cannot lean back and be satisfied. There are still a lot of improvements to make and the other modes of transport improve as well. Estimations we made within an EU project some years ago indicate that the green house gas emissions from railway traffic can be further reduced with almost 50 % until 2050.

Finally Gerhard Troche, policy officer at the EU talked about the 4th railway package, European freight corridors and the upcoming research project Shift2Rail. No country can today solve its problems on its own, co-operation is a must. The KTH Railway Group is looking forward to intensify the contact with European but also non-European partners.

This status report gives an impression of the diversity of activities in research and education that are carried out. We hope you find some interesting projects. If you have any questions do not hesitate to contact me or any other member of the KTH Railway Group.

Professor Sebastian Stichel
Director

September 2013

Professor Sebastian Stichel, Director of the KTH Railway Group

The Board 2013

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

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Not present on photo: Christel Wiman and Pontus Gruhs

Research groups 2013

SCHOOL OF ENGINEERING SCIENCES

Rail Vehicles – Professor Mats Berg
Vehicle Dynamics – Associate Professor Lars Drugge
MWL (Sound and Vibrations) – PhD Ulf Carlsson
Lightweight Structures – Associate Professor Per Wennhage

SCHOOL OF ARCHITECTURE AND BUILT ENVIRONMENT

Traffic and Logistics – Adjunct Professor Bo-Lennart Nelldal, from August 2013 PhD Oskar Fröidh
Structural Engineering and Bridges – Professor Raid Karoumi
Highway and Railway Engineering – Professor Björn Birgisson

SCHOOL OF INDUSTRIAL ENGINEERING AND MANAGEMENT

Machine Design – Professor Ulf Olofsson

SCHOOL OF ELECTRICAL ENGINEERING

Electrical Machines and Power Electronics – Professor Stefan Östlund

The Board members 2013


Henrik Tengstrand


Susanne Rymell


Raid Karoumi


Mats Berg


Stefan Östlund


Hugo von Bahr


Roger Lundén


Michael Than


Bo-Lennart Nelldal


Rickard Nilsson


Tohmmy Bustad


Sebastian Stichel

Not present on photo: Christel Wiman and Pontus Gruhs

Railway Education at KTH Railway Group

In five of the KTH Railway Groups divisions courses in the Railway sector are given, i.e. from the divisions for Rail Vehicles, Traffic & Logistics, Road and Railway Engineering, Structural Engineering and Bridges, and Electric Power Engineering. Our courses are carried out in three different forms of training.

These program courses are part of the the Bachelor or Master (or Civilingenjör) Educations here at KTH. It is also possible to make a Bachelor or Master Thesis at our divisions.

There are also courses for external students including courses within further education here at KTH. That is some of the program courses that are also open to external and the teaching is carried out together with the KTH students. These courses are presented and are searchable by www.studera.nu (SD2307, SD2313 and EJ2400 below).

The third course form is training for company development. They are given on request from companies by our Divisions. Please contact the Professor or Director of Studies of the Division.

We also started a co-operation with the University of Illinois in Urbana Champaign during the last two years. It is now possible for our master students to participate in their classes and the KTH class in Rail Vehicle Dynamics was given at UIUC spring 2013.

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Railway Traffic Planning at division of Traffic and Logistics
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Division of Road and Rail Engineering
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Division of Structural Engineering and Bridges
Raid Karoumi 08-790 90 84 raid.karoumi@byv.kth.se

Division of Electrical Machines and Power Electronics
Stefan Östlund 08-790 77 45 stefan.ostlund@ee.kth.se

Railway Courses in 2013-2014

Division of Rail Vehicles

SD2221 Fordonssystemteknik (8 hp)
Vehicle System Technology

SD2307 Spårfordonsteknik (7,5 hp)
Rail Vehicle Technology

SD2313 Spårfordons dynamik (8 hp)
Rail Vehicle Dynamics

Railway Traffic Planning Group at division of Traffic and Logistics

AH1025 Kollektivtrafiksystem, bussar och spårtrafik, gk 7,5 hp
Public Transport Systems, Buses and Rail, BC

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

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

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

Division for Road and Rail Engineering

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

AH1907 Anläggning 1. Väg-, järnväg och VA-teknik 7,5 hp
Installation1. Road, Railways and Wastewater Networks

AH1908 Anläggning 2. Byggande drift och underhåll av vägar och järnvägar 7,5 hp.
Installation2. Construction, Management and Maintenance of Roads and Railsways

Division for Structural Engineering and Bridges

AF2011 Structural Dynamics for Civil Engineers (7,5 hp)

AF2201 Brokonstruktion (7,5 hp)
Bridge Design

AF2203 Brokonstruktion fk (7,5 hp)
Bridge Design, Advanced Course

Division for Electric Power Engineering

EJ2400 Elektrisk traktion (7,5 hp)
Electric Traction

More information on the web-site for KTH Railway Group at www.railwaygroup.kth.se

PhD theses at the KTH Railway Group 1995–2013

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.

26. Esra Bayoglu Flener: Static and dynamic behaviour of soil-steel composite bridges obtained by field testing, 2009.

27. Johan Wiberg: Railway bridge response to passing trains. Measurements and FE model updating, 2009.

28. Jon Sundh: On wear transitions in the wheel-rail contact, 2009.

29. Olov Lindfeldt: Railway operational analysis. Evaluation of quality, infrastructure and timetable on single track and doubletrack lines with analytical models and simulation. 2010.

30. Andreas Andersson: Capacity assessment of arch bridges with backfill: Case of the old Årsta railway bridge, 2011.

31. Rickard Persson: Tilting trains – Enhanced benefits and strategies for less motion sickness, 2011.

32. Anneli Orvnäs: On Active Secondary Suspension in Rail Vehicles to Improve Ride Comfort, 2011.

33. Lars Abrahamsson: Optimal Railroad Power Supply System Operation and Design, 2012.

34. David Wennberg: Multi-Functional Composite Design Concepts for Rail Vehicle Car Bodies, 2013.

Rail Vehicles – RV

Professor
Mats Berg

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 pantograph-catenary interaction, energy consumption and running times. In addition, the division is responsible for two graduate courses and also external courses. A Master Programme on Vehicle Engineering, covering both rail and road vehicles, started in the autumn of 2010.

RESEARCH PROJECTS

RV1. Running gear for freight wagons

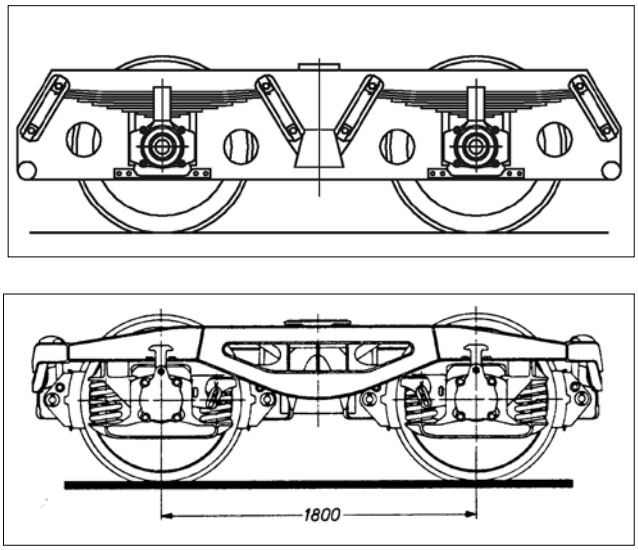
Project leader	Sebastian Stichel
Scientists	Per-Anders Jönsson
	Evert Andersson
	Saeed Hossein Nia

Sources of funding: Trafikverket, Bombardier, SLL, Tågoperatörerna, Interfleet Technology, LKAB.

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-axle wagons on track. Speeds up to 170 km/h have been tested.

In 2010 work on modelling the latest iron ore wagon from MTAB/LKAB with so called three-piece bogies started. The aim of this part of the project is to be able to study different types of phenomena with help of multibody simulation instead of only with on-track tests to save time and money. One of the major difficulties when modelling three-piece bogies is a correct mathematical description of the friction damping. The first study conducted was to find the reasons for the increase of the frequency of Rolling Contact Fatigue during winter. The results were presented on the IHHA conference in New Delhi in February 2013.

Saeed Hossein Nia in front of an iron ore locomotive.



Examples of running gear investigated.

Jönsson P-A and 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 and Stichel S: On the Influence of Freight Traffic Operational Conditions on Track Deterioration cost. Proceedings of International Heavy Haul Conference, p 445-452, Kiruna, June11-13, 2007.

Jönsson P-A: Dynamic Vehicle-Track Interaction of European Standard Freight Wagons with Link Suspension, Ph.D. Thesis, Report TRITA AVE 2007:36, KTH Rail Vehicles, 2007. ISBN 978-91-7178-727-9.

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

Jönsson P-A and Stichel S: On the Influence of Freight Traffic Operational Conditions on Track Deterioration Cost. International Journal of COMADEM, 12(2), pp 3-9, April 2009.

Stichel S and Jönsson P-A: Is there a Future for Freight Wagon with Link Suspension? Proc. of the 9th International Heavy Haul Conference, IHHA´09. Shanghai, China, June 22 - 24, 2009.

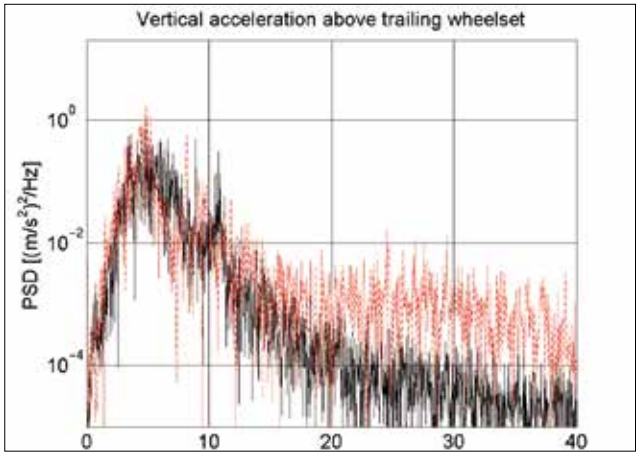
Andersson E and Öberg J: Models for infrastructure costs related to the wheel-rail interface. Chapter 21 in Wheel-rail interface handbook, Woodhead Publishing Ltd, Cambridge, England, 2009.

Öberg J and Andersson E: Determining the deterioration cost for railway tracks. Proc. IMechE Vol 223 No F2, J. Rail and Rapid Transit, pp. 121-129, 2009.

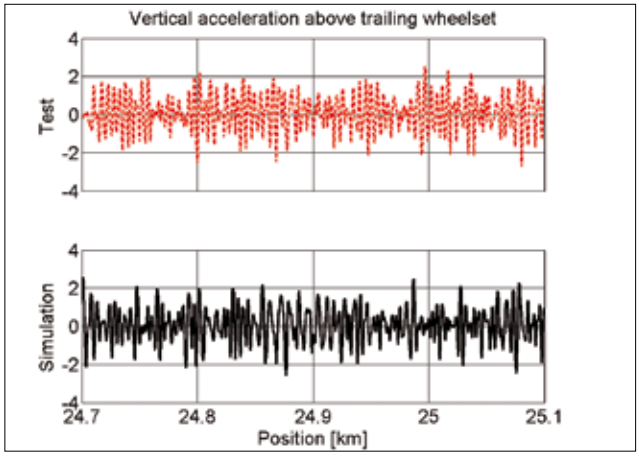
Bogojevic N., Jönsson P-A and Stichel S: Iron Ore Transportation Wagon with Three-Piece Bogies – Simulation Model and Validation. HEAVY MACHINERY - HM 2011, ISBN 978-86-82631-45-3.

Hossein Nia S., Stichel, S., Jönsson P.-A., Nordmark, T., Bogojevic, N: Can simulation help to find the sources of wheel damages? Proc. of 10th International Heavy Haul Conference. New Delhi, February 2013.

Three-piece bogie.



Comparison between measured and simulated results...



... for two-axle vehicle with link suspension.

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

Project leader	Roger Enblom
Scientists	Babette Dirks
	Roger Enblom
	Mats Berg

Sources of funding: Trafikverket, Bombardier Transportation, SLL, Tågoperatörerna, Interfleet Technology, Vectura.

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 Florence paper available models for prediction of rolling contact fatigue are evaluated and some trial simulations and parameter studies are reported. In the Cape Town paper further parametric studies and accumulated damage comparisons related to the Stockholm commuter service are carried out. The performance of two vehicle concepts, two wear models, and two RCF models is evaluated and vehicle related as well as model related differences are addressed.

Extensive recording of wear and RCF development on wheels and rails of the Stockholm commuter operation, selected as the reference application, has been carried out during the last two years. The objective of the ongoing work is to arrive at a calibrated RCF model using crack and rail profile measurements, tentatively for the iron ore line in northern Sweden.

Papers

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

Enblom R and Stichel S: Industrial implementation of novel procedures for prediction of railway wheel surface deterioration. Proceedings of the 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, Florence, September 15-18, 2009.

Iwnicki S, Björklund S and Enblom R: Wheel-rail contact mechanics. Chapter 3 in Wheel-rail interface handbook, Woodhead Publishing Ltd, Cambridge, England, 2009.

Dirks B and Enblom R: Prediction of wheel profile wear and rolling contact fatigue for the Stockholm commuter train. Proceedings of the 16th International Wheelset Congress, Cape Town, March 14-19, 2010.

Enblom R: Getting to the root of wheel wear. Railway Gazette, March 2010.

Dirks B and Enblom R: Prediction model for wheel profile wear and rolling contact fatigue. Accepted for publication in Wear. Wear 271, issues 1-2, pp. 210-217, May 2011. (Available online October 16, 2010).

Enblom R and Stichel S: Industrial implementation of novel procedures for prediction of railway wheel surface deterioration. Wear 271, issues 1-2, pp. 203-209, May 2011. (Available online October 12, 2010)

Papers related to the preceeding project in this area,"Wear on wheels and rails" (SAMBA 2):

Enblom R: On Simulation of Uniform Wear and Profile Evolution in the Wheel-Rail Contact, Ph.D. Thesis, Report TRITA AVE 2006:83, KTH Rail Vehicles, 2006. ISBN 978-91-7178-605-3.

Since then, the following papers have been published:

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

Enblom R and 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, Vol 47/6, pp 661-700, 2009.

RV3. Modelling of rail vehicle dynamics

Project leader	Mats Berg
Scientists	Nizar Chaar
	Mats Berg

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

This project aimed at developing improved mathematical models for analysing the vehicle-track dynamics interaction. The work was focused on wheelset structural flexibility and track flexibility, and in particular with respect to wheel-rail forces up to say 200 Hz. Simulated results were compared with measured ones, both on component level and on the global vehicle-track level. Two case studies were selected for the studies: An Rc locomotive and the Green Train running on two different straight tracks. Track flexibility was measured at both sites and the wheelset structural flexibility was measured in laboratory. It is concluded that both types of flexibility have a significant influence on the vehicle-track dynamics and should be properly modelled and included in vehicle-track interaction simulations.

Chaar N and Berg M: Experimental and numerical modal analyses of a loco wheelset, Proceedings of the 18th IAVSD Symposium on dynamics of vehicles on roads and on tracks, Vehicle System Dynamics Supplement, 41 (2004), pp. 597-606.

Chaar N and Berg M: Vehicle-track dynamic simulations of a locomotive considering wheelset structural flexibility and comparison with measurements, Proc IMechE Part F: Journal of Rail and Rapid Transit, Vol. 219, pp. 225-238, December 2005.

Claesson S: Modelling of Track Flexibility for Rail Vehicle Dynamics Simulation, Master Thesis, Report TRITA AVE 2005:26, Division of Railway Technology, Department of Aeronautical and Vehicle Engineering, Royal Institute of Technology (KTH), Stockholm 2005.

Polach O, Berg M and Iwnicki S: Simulation. Chapter 12 in Handbook of Railway Vehicle Dynamics, Taylor & Francis, 2006.

Chaar N and Berg M: Simulation of vehicle-track interaction with flexible wheelsets, moving track models and field tests, Proceedings of the 19th IAVSD Symposium on dynamics of vehicles on roads and on tracks, Vehicle System Dynamics Supplement, 44 (2006), pp. 921-931.

Chaar N: Wheelset Structural Flexibility and Track Flexibility in Vehicle-Track Interaction, Ph.D. Thesis, Report TRITA AVE 2007:17, KTH Rail Vehicles, 2007. ISBN 978-91-7178-636-4.

Chaar N and Berg M: Dynamic wheel-rail force measurements and simulations of a high-speed train running on two tracks with different flexibility and irregularities, submitted for publication.

RV4. Track stiffness, irregularities and maintenance

Project leader	Mats Berg and Eric Berggren
Scientists	Eric Berggren (Banverket)
	Mats Berg et al.

Sources of funding: Banverket/Trafikverket.

The overall aim of this project was to use measurement results of vertical track stiffness along the track to improve the track maintenance, in particular with respect to track irregularities. The track stiffness was measured by a special-purpose rebuilt two-axled freight wagon running on the track at speeds up to 50 km/h and exciting one of the axles by harmonic or "white noise" loading. To some extent results from ground penetrating radar was also used to suggest proper track maintenance actions or soil reinforcements. The project was partly integrated with the EU project INNOTRACK, for instance by using the test wagon above on tracks in France and Germany.

Berggren E, Jahlénius Å, Bengtsson B-E and Berg M: Simulation, Development and Field Testing of a Track Stiffness Measurement Vehicle, Proceedings of 8th International Heavy Haul Conference, Rio de Janeiro, 13-16 June, 2005. ISBN 0-646-33463-8.

Smekal A, Berggren E and Silvast M: Monitoring and Substructure Condition Assessment of Existing Railway Lines for Upgrading to Higher Axle Loads and Speeds, Proceedings of 7th World Congress on Railway Research, Montreal, 5-7 June, 2006.

Berggren E: Measurements of Track Stiffness and Track Irregularities to Detect Short Waved Support Conditions, Proceedings of International Conference on Railway Track Foundations, Birmingham, 11-13 September, 2006. ISBN 0-704426-00-5.

Berggren E, Li M and Spännar J: A New Approach to the Analysis and Presentation of Vertical Track Geometry Quality and Rail Roughness, Proceedings of 7th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2006), Brisbane, 24-27 September, 2006. Also in journal of WEAR, Vol 265, pp 1488-1496, 2008.

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Berggren E: Efficient Track Maintenance - Methodology for Combined Analysis of Condition Data, Proceedings of 9th International Heavy Haul Conference, Shanghai, 2009. Also in Proc IMechE Part F: Journal of Rail and Rapid Transit, Vol. 224, pp. 353-360, September 2010.

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Berggren E, Kaynia A and Dehlbom B: Identification of Substructure Properties of Railway Tracks by Dynamic Stiffness Measurements and Simulations, Journal of Sound and Vibration, Vol. 329, pp. 3999-4016, 2010.

RV5. Dynamic instability and discomfort of high-speed trains due to aerodynamics in tunnels

Project leader	Mats Berg
Scientists	Ben Diedrichs
	Sinisa Krajnovic
	Mats Berg

Sources of funding: Banverket

In this project high-speed train aerodynamics inside tunnels was mainly studied. Through computational fluid dynamics and multibody vehicle simulations it has been found that the rear coaches of high-speed trains can start oscillating laterally when negotiating tight and long tunnels. This has also been confirmed in Japanese measurements. The oscillations are annoying and discomforting. Careful design of the train tail geometry can mitigate the discomfort. Crosswind stability of rail vehicles was also studied through simulations and wind tunnel measurements, for instance considering track embankments.

Diedrichs B: On computational fluid dynamics modelling of crosswind stability for high-speed rolling stock. Proc. Instn Mech. Engrs, Part F: J. Rail and Rapid Transit 217(F3), 203–226, 2003.

Diedrichs B, Ekequist M, Stichel S and Tengstrand H: Quasi-static modelling of wheel–rail reactions due to crosswind effects for various types of high-speed rolling stock. Proc. Instn Mech. Engrs, Part F: J. Rail and Rapid Transit, 218 (F2), 133–148, 2004.

Diedrichs B, Berg M and Krajnovic S: Large eddy simulations of a typical European high-speed train inside tunnels. SAE 2004-01-0229, 2004.

Diedrichs B, Berg M and Krajnovic S: Large eddy simulations of the flow around high-speed trains cruising inside tunnels. European Congress on Computational Methods in Applied Sciences and Engineering. ECCOMAS. P. Neittaanmäki, T. Rossi, S. Korotov, E. Oñate, J. Périaux, and D. Knörzer (eds.) Jyväskylä, 24–28 July, 2004.

Diedrichs B: Studies of Two Aerodynamic Effects on High-Speed Trains: Crosswind Stability and Discomforting Car Body Vibrations Inside Tunnels, Ph.D. Thesis, Report TRITA AVE 2006:81, KTH Rail Vehicles, 2006.

Diedrichs B, Sima M, Orellano A and Tengstrand H: Crosswind stability of a high-speed train on a high embankment. Proc. Instn Mech. Engrs, Part F: J. Rail and Rapid Transit, 221 (F2), 205–225, 2007.

Diedrichs B, Berg M, Stichel S and Krajnovic S: Vehicle dynamics of a high-speed passenger car due to aerodynamics inside tunnels. Proc. Instn Mech. Engrs, Part F: J. Rail and Rapid Transit, 221 (F4), 527–545, 2007.

Diedrichs B, Krajnovic S and Berg M: On the aerodynamics of car body vibrations of high-speed trains cruising inside tunnels. Journal of Engineering Applications of Computational Fluid Mechanics. Volume 2, Number 1, pp 51-75, 2008. ISSN 1994-2060.

RV6. Robust safety systems for trains

Project leader	Evert Andersson
Scientists	Dan Brabie
	Evert Andersson

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

This research project aimed 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 was studied, e.g. whether the train stays upright close to the track centre or deviates laterally with probably serious consequences. Conclusions were drawn from an interactive process where multi-body computer simulations were performed and compared with real incidents and accidents. Different train design parameters were systematically investigated by means of in this way validated simulation models. The vehicle behaviour associated with derailments was 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, but publications are available also after that.

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. Also In Vehicle System Dynamics, Vol 46, Supplement, pp 289-300, 2008.

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, Ph.D. Thesis, Report TRITA AVE 2007:78, KTH Rail Vehicles, 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 seminariet för Järnvägsteknik, Hook, 22-23 maj 2008.

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.

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. Journal of Rail and Rapid Transit, Vol 223, p 543-566, 2009.

consequences of a train derailment. 15:e Nordiska seminariet för Järnvägsteknik, Hook, 22-23 maj 2008.

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

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. Journal of Rail and Rapid Transit, Vol 223, p 543-566, 2009.

RV7. Simulation of energy consumption and running time of trains

Project leader	Piotr Lukaszewicz
Scientists	Piotr Lukaszewicz
	Evert Andersson
	Mats Berg

Sources of funding: Banverket/Trafikverket.

This project was partly based on measurements of running resistance of different passenger and freight trains. A software was developed to calculate train energy consumption and running time for selected trains and railway lines. Emphasis has been put on driver style and how it can effect the energy consumption and running time; a number of different driver models have been formulated for that purpose promoting so-called eco driving. The project has been integrated with the EU project Railenergy in the context of energy efficient timetabling.

Lukaszewicz P: SimERT Project - Simulation of Energy Usage and Running Time for Trains. 2nd UIC Energy Efficiency Conference, Paris, 4-5 February 2004.

Lukaszewicz P: Energy Saving Driving Methods for Freight Trains. Computers in Railways IX. Advances in Transport Vol. 15. ISBN 1-85312-715-9. Presented in Dresden, Germany, 2004.

Andersson E and Lukaszewicz P: Energy consumption and related air pollution for Scandinavian electric passenger trains. Report TRITA AVE 2006:46, KTH Rail Vehicles, 2006.

Lukaszewicz P: Impact of train model variables on simulated energy usage and journey time. Computers in Railways X. WIT Transactions on The Built Environment, Vol. 88, 2006. ISBN 1-84564-177-9.

Lukaszewicz P: Running resistance - results and analysis of full-scale tests with passenger and freight trains in Sweden. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit, Vol 221, No 2, pp 183-192, 2007.

Lukaszewicz P: A simple method to determine train running resistance from full-scale measurements. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit, Vol 221, No 3, pp 331-337, 2007.

Lukaszewicz P: Running Resistance of Ore Trains in Sweden. High Tech in Heavy Haul. Proceedings of IHHA 2007, pp 111-120, Kiruna, Sweden, 2007. ISBN 978-91-633-0607-5.

Lukaszewicz P: Energy and Power Efficient Timetabling - Results from Information Search. Railenergy deliverable NRG-KTH-D-2.3-001.003. December 2007.

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Lukaszewicz P: Methods and Models for Energy Efficient Driving - Algorithms. Railenergy deliverable NRG-KTH-D-2.3-005. June 2008.

Lukaszewicz P: Projekt SimERT- Fas 2, Sammanfattande slutrapport för perioden 2005-01--2008-12. Report TRITA AVE 2008:72, KTH Rail Vehicles, 2008.

Lukaszewicz P: Running resistance and energy consumption of ore trains in Sweden. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit. Special Issue. Vol 223, No 2, pp 189-197, 2009.

RV8. Train Information, Management and Monitoring (TIMM)

Project leader	Stefan Östlund
Scientists	Tobias Forsberg
	Mats Berg
	Sebastian Stichel et al.

Sources of funding: Vinnova, Banverket/Trafikverket, Bombardier Transportation.

This project focused on vehicle-track dynamic interaction and how it can be monitored, in particular from vehicle based systems. Phenomena that may vary along the track, for instance ride instability and ride discomfort, were of special interest. A case study with a Regina EMU train has been studied in this context.

Forsberg T: Condition monitoring of railway mechanics with focus on train ride stability, M.Sc. Thesis, Report TRITA AVE 2006:107, KTH Rail Vehicles, 2006.

Forsberg T, Berg M, Stichel S and Andersson E: Condition monitoring of train ride stability. BOGIE'07, Budapest, 3-6 September, 2007. Proceedings of the 7th International Conference on Railway Bogies and Running Gears, pp 271-280.

RV9. Crosswind stability and unsteady aerodynamics in vehicle design

Project leader	Mats Berg
Scientists	Dirk Thomas
	Mats Berg
	Ben Diedrichs
	Sebastian Stichel et al.

Sources of funding: KTH, Vinnova, Scania, Volvo, Saab, Bombardier, A2Zound, VTI, Trafikverket. This is a project within the Vinnova Centre for ECO2 Vehicle Design.

This project comprises both vehicle aerodynamics and vehicle dynamics, and is applied to both rail and road vehicles. A significant challenge is to carry out unsteady fluid dynamics simulations, supporting the vehicle dynamics studies including overturning risk. A case study selected for the rail application is the Green Train, making use of the field tests carried out in recent years to investigate the lateral dynamics in more detail. Wind gusts have then been introduced in the simulations to investigate various overturning scenarios. Furtheron a stand-still vehicle has been subjected to lateral carbody loads imitating crosswind and evaluating the vehicle response, both through measurements and simulations. Currently work is ongoing on active suspension to improve vehicle crosswind stability. The overall goal of the project is to suggest less wind sensitive vehicle designs, mainly through the external shaping as well as the vehicle mass and suspension properties.

Favre T and Thomas D: Transient Crosswind Stability of Vehicles – A Literature Survey, Report TRITA AVE 2007:60, Centre for ECO2 Vehicle Design, KTH, 2007.

Diedrichs B: Aerodynamic Calculations of Crosswind Stability of a High-Speed Train using Control Volumes of Arbitrary Polyhedral Shape, VI International Colloquium on Bluff Bodies Aerodynamics & Applications (BBAA), Milan, 20-24 July, 2008. A corresponding paper has also been published.

Thomas D, Berg M and Stichel S: Measurements and Simulations of Rail Vehicle Dynamics with respect to Overturning Risk, XXII International Congress of Theoretical and Applied Mechanics (ICTAM), Adelaide, 24-29 August, 2008. Also in Vehicle System Dynamics, Vol 48, No 1, pp 97-112, January 2010.

Favre T, Efraimsson G and Diedrichs B: Numerical Investigation of Unsteady Crosswind Vehicle Aerodynamics using Time-Dependent Inflow Conditions, 7th MIRA International Vehicle Aerodynamics Conference, Coventry, 22-23 October, 2008.

Diedrichs B: Unsteady Aerodynamic Crosswind Stability of a High-Speed Train Subjected to Gusts of Various Rates, Euromech Colloquium 509: Vehicle Aerodynamics – External Aerodynamics of Railway Vehicles, Trucks, Buses and Cars, Berlin, 24-25 March 2009. A corresponding paper has also been accepted.

Favre T, Diedrichs B and Efraimsson G: Detached-Eddy Simulations applied to Unsteady Crosswind Aerodynamics of Ground Vehicles, 3rd Symposium on Hyrbrid RANS-LES Methods, Gdansk, June 2009.

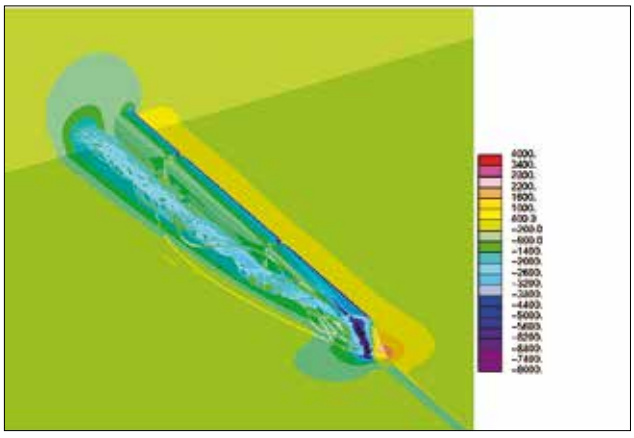
Thomas D, Diedrichs B, Berg M and Stichel S: Dynamics of a High-Speed Rail Vehicle Negotiating Curves at Unsteady Crosswind, paper presented at 21st International Symposium on Dynamics of Vehicles on Roads and Tracks (IAVSD´09), Stockholm, 17-21 August 2009.

Thomas D: Lateral stability of high-speed trains at unsteady crosswind, Licentiate Thesis, Report TRITA AVE 2009:79, KTH Rail Vehicles, 2009. ISBN 978-91-7415-473-3.

Diedrichs B: Aerodynamic crosswind stability of a regional train model, Proc. IMechE Journal of Rail and Rapid Transit, Vol 224, pp 580-591, November 2010.

Thomas D, Diedrichs B, Berg M and Stichel S: Dynamics of a high-speed rail vehicle negotiating curves at unsteady crosswind, Proc. IMechE Journal of Rail and Rapid Transit, Vol 224, pp 567-579, November 2010.

Thomas D., Berg M., Diedrichs B. and Stichel S.: Rail Vehicle Response to Lateral Carbody Excitations Imitating Crosswind, 22nd International Symposium on Dynamics of Vehicles on Roads and Tracks (IAVSD´11), Manchester, UK, 15-19 August 2011. Also accepted in extended version for publication in Journal of Rail and Rapid Transit.



CFD calculation of train in strong crosswind.

RV10. Gröna Tåget (Green Train) : Programme management

Research leader Evert Andersson

Sources of funding: Banverket/Trafikverket

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 knowledge and technologies 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 seminariet 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.

Andersson E: Gröna Tåget - för konventionella banor och framtida höghastighetsbanor. Nordic Rail, Jönköping (Sweden), October 2009.

Gröna Tåget - Trains for tomorrow's travellers. KTH, Banverket and Bombardier Transportation, Information broschure 16 p, Stockholm, December 2010.

Fröidh O: Green train - Basis for a Scandinavian high-speed train concept, Final Report, Part A, Publication 12-01, KTH Railway Group, 2012.

Andersson E: Green train - Concept proposal for a Scandinavian high-speed train, Final Report, Part B, Publication 12-02, KTH Railway Group, 2012.

Gröna Tåget - Trains for tomorrow's travellers. KTH, Banverket and Bombardier Transportation, Information broschure 16 p, Stockholm, December 2010.

RV11. Gröna Tåget: Track-friendly bogies

Project leader Evert Andersson

Scientists Anneli Orvnäs
Rickard Persson
Evert Andersson

Sources of funding: Banverket/Trafikverket

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: Developent of Track-Friendly Bogies for High Speed – A Simulation Study, Publ 0703 KTH Railway Group, 2007. 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, October 2007.

Andersson E, Orvnäs A and Persson R: On the Optimization of a Track-Friendly Bogie for High Speed, Proceedings of the 21st International Symposium on Dynamics of Vehicles on Roads and Tracks, IAVSD'09, Stockholm, August 17-21, 2009.

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

Project leader	Evert Andersson
	Mats Berg
Scientists	Rickard Persson
	Evert Andersson
	Mats Berg
	Björn Kufver (Ferroplan)

Sources of funding: Banverket/Trafikverket, Bombardier Transportation, SL AB, Tågoperatörerna, Interfleet Technology, Vinnova, VTI.

This project aimed at investigating possibilities for improved performance of rail vehicles equipped with a carbody tilt system. Firstly a review was 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 was made on possible causes for motion sickness in tilting trains, presently being a major limitation of tilted vehicles. Suitable improvements in the vehicle technology have been investigated as well as suggestions for suitable track geometry parameters. In particular a more advanced choice of tilting angle is studied. Field tests, including test subjects, were carried out in 2010 and a PhD thesis presented in 2011.

Kufver B and Persson R: On enhanced tilt strategies for tilting trains, Proceedings of Comprail 2006, pp 839-848. WIT Press, Southampton 2006.

Persson R: Spårvänliga boggier och korglutning, Transportforum 2007.

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

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

Persson R: Research on the competitiveness of tilting trains, Proc of Railway Engineering 2007, Engineering Technical Press, Edinburgh 2007.

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

Persson R: Åksjuka i korglutande tåg. Transportforum, Linköping 2008.

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

Persson R: Tilting trains – Technology, benefits and motion sickness. Licentiate Thesis, Report TRITA AVE 2008:27, KTH Rail Vehicles, 2008. ISBN 978-91-7178-972-3.

Persson R: Motion sickness in tilting trains, Proc of the 43rd UK Conference on Human Response to Vibration, Leicester 2008.

Persson R: Motion sickness on-track test evaluation, Proc of the 43rd UK Conference on Human Response to Vibration, Leicester 2008.

Persson R, Goodall R M and Sasaki K: Carbody tilting - Technologies and benefits. State-of-the-Art Paper of the 21st IAVSD Symposium, Vehicle System Dynamics, Vol 47, No 8, pp 949-981, August 2009.

Persson R: Weighting curves to motion sickness, Proc of the 44th UK Conference on Human Response to Vibration, Loughborough 2009.

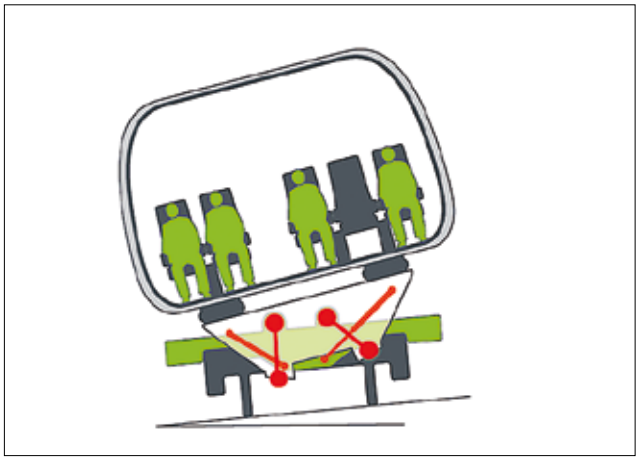
Persson R: Tilting trains - benefits and motion sickness, Proc. IMechE Journal of Rail and Rapid Transit, Vol 224, pp 513-522, November 2010.

Persson R, Kufver B: Strategies for less motion sickness on tilting trains, Proceedings of Comprail 2010, pp 581-591. WIT Press, Southampton 2010.

Persson R: Tilting trains – Enhanced benefits and strategies for less motion sickness. Doctoral Thesis, Report TRITA AVE 2011:26, KTH Rail Vehicles, 2011. ISBN 978-91-7415-948-6.

Persson R, Kufver B and Berg M: On-track test of tilt control strategies for less motion sickness on tilting trains, Vehicle System Dynamics, Vol 50, No 7, pp 1103-1120, London 2012.

Persson R, Kufver B and Berg M: Improving the competitiveness of tilting trains, Proceedings of STECH Conference 2012.



Principle of car body tilt

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 was made on human annoyance of different characters of railway noise, as radiated to the surrounding environment. This was 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 were normalized with respect to duration and A-weighted sound pressure level. The results 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/Trafikverket

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 possbile to reduce energy consumption by 25 – 40 % both on the existing railway network and on future high-speed lines - despite of 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.

Lukaszewicz P and Andersson E: Green Train energy consumption - Estimations on high-speed rail operations, Publication 0901, KTH Railway Group, 2009. ISBN 978-91-7415-257-9.

Sjöholm M: Benefits of regenerative braking and eco driving for high-speed trains -- Energy consumption and brake wear, MSc thesis, TRITA AVE 2011:23, KTH Rail Vehicles, 2011. ISBN 978-91-7415-920-2

RV15. Gröna Tåget: Active lateral suspension

Project leader	Sebastian Stichel
Scientists	Anneli Orvnäs
	Rickard Persson
	Alireza Qazizadeh
	Sebastian Stichel

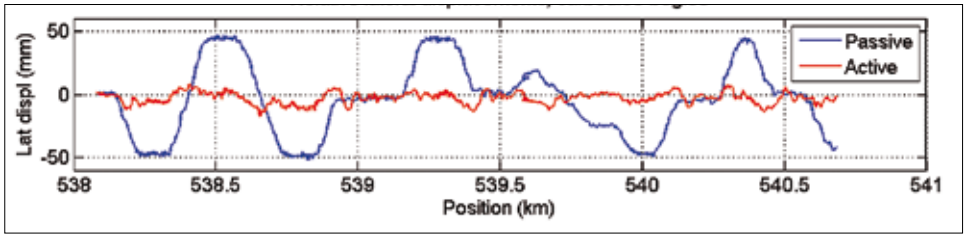
Sources of funding: Trafikverket, Bombardier, SJ, SLL, Interfleet, Vectura

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 has been implemented in long-term tests in service operation. A Regina train with active lateral suspension has been operating from March 2009 until the beginning of 2013. In 2011 Anneli Orvnäs defended her PhD thesis with the title "On Active Secondary Suspension in Rail Vehicles to Improve Ride Comfort".

In 2012 a new PhD student, Alireza Qazizadeh, started within the project. The first task was to perform the simulations for the design of the controller for tests on active vertical secondary suspension. The tests were carried out in May 2013 with very promising results. The vertical ride comfort could be improved with 20%-30%.

Orvnäs A, Stichel S and Persson R: Improving Ride Comfort in Trains with Active Suspension. 15:e Nordiska Seminariet i Järnvägsteknik, Jönköping, May 23, 2008.



Relative lateral displacement between carbody and bogie with and without active lateral suspension.

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.

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Orvnäs A: Active lateral secondary suspension in a high-speed train to improve ride comfort, Licentiate Thesis, KTH Rail Vehicles, 2009. ISBN 978-91-7415-300-2.

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Orvnäs A, Stichel S and Persson R: Ride Comfort Improvements of a REGINA Train with Active Lateral Secondary Suspension,

Anneli Orvnäs on the Green Train during measurements with active suspension.

Proceedings of the 8th International Conference on Railway Bogies and Running Gears, BOGIE '10, Budapest, Hungary, September 13-16, 2010.

Orvnäs A, Stichel S and Persson R: Active Lateral Secondary Suspension with H∞ control to Improve Ride Comfort: Simulations on a Full-Scale Model, Vehicle System Dynamics, online publication (DOI: 10.1080/00423114.2010.527011), 2011.

Orvnäs A, Stichel S, Persson R. Aspects of Using Active Vertical Secondary Suspension to Improve Ride Comfort. In: 22nd International Symposium on Dynamics of Vehicles on Roads and Tracks, IAVSD'11. Manchester, August 14-19, 2011.

Orvnäs, A. On Active Secondary Suspension in Rail Vehicles to Improve Ride Comfort. PhD thesis KTH. Trita-AVE, ISSN 1651-7660; 2011:79. Stockholm, 2011.

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

Project leader Sebastian Stichel

Scientists Per-Anders Jönsson
Sebastian Stichel
Lars Drugge
Mats Berg

Sources of funding: Trafikverket

The overhead power system has been identified as one of the critical areas when increasing train speed especially on upgraded Swedish lines.

Several questions cannot 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 has been studied mainly by use of computer simulation. An existing 2-D model has been extended to a 3-D model.

The potential to reduce contact force variation with help of actively controlled pantographs has been Investigated within two master theses.

Within the last year KTH participated in an international benchmark study with the aim to compare simulation results of a large number of codes worldwide. The first stage of the benchmark is finished. The results are presented on the IAVSD conference in Qingdao in 2031.

Bucca, G., Carnevale, M., Collina, A ., Facchinetti, A Drugge, L., Jönsson, P.-A., Stichel, S.: Differentiation of pantograph´s preloads as a mean to improve multiple collection and speed up.existing lines. Proc.of 22nd Symposium of the International Association for Vehicle System Dynamics, IAVSD. Manchester. 14-19 August. 2011.

Tieri R., Collina A., Carnevale M., Stichel S, Jönsson P.-A. Pneumatic active control system for pantograph catenary interaction. Accepted for presentation at WCRR, Sydney, Australia, 2013.

Bruni, S. et.al. The Pantograph-Catenary Interaction Benchmark .Proc. of 23rd Symposium of the International Association for Vehicle System Dynamics, IAVSD. Qingdao, 19-23 August 2013.

RV17. Collaboration In Research and development of new Curriculum In Sound and vibration (CIRCIS)

Project leader	Mats Berg
Scientists	Shafiq Khan
	Mats Åbom
	Hans Bodén et al.

Sources of funding: European Commission (FP6), SIDA (Swedish Research Link Programme)

This was a collaboration between two European universities, KTH and Loughborough University, and two Indian universities, Indian Institute of Technology in Delhi respectively in Roorkee. The overall project goal was twofold: Curriculum development in sound and vibration, and research work on the influence of low frequency vibrations on activity comfort while travelling by railway vehicles. An important project element was also student mobility (exchange). The description and references below focus on the research part, for which extensive field and laboratory measurements have been carried out. For the latter part a test chamber was developed with a platform vibrating in different directions and on which seated test subjects are evaluated with respect to activity performance, for instance reading and writing/sketching.

Narayanmoorthy R, Khan S, Berg M, Goel V K, Saran V H and Harsha S P: Determination of Activity Comfort in Swedish Trains. Presented at World Congress on Railway Research, Seoul, South Korea, May 2008.

Harsha S P, Saran V H, Goel V K and Berg M: Nonlinear Vibration Signature Analysis of Rail Bearing Systems. 12th Nonlinear Vibration, Dynamics and Multi-body Systems, Virginia Tech, Blacksburg (USA), June 1-5, 2008.

Khan S, Ulhas M and Goel V K: Synthesis of Passby Railway Noise. Acoustics-08 Congress, Paris, June 29 - July 4, 2008.

Bhiwapurkar M K, Saran V H, Goel V K and Berg M: Influence of multi-axis random vibrations on reading activity. Presented at the 4th International Conference on Whole Body Vibration Injuries, Montreal, Canada, June 2-4, 2009.

Bhiwapurkar M K, Saran V H, Goel V K, Mansfield N and Berg M: Study of Human Comfort under Thermal and Vibratory Environment using Physiological Indices. Presented at 16th International Congress on Sound and Vibration, Krakow, 5-9 July 2009.

Bhiwapurkar M K, Singh G, Choudhary S, Saran V H, Goel V K and Berg M: Influence of whole body vibrations on sketching performance. Presented at 21st International Symposium on Dynamics of Vehicles on Roads and Tracks, 17 – 21 August 2009, Stockholm.

Bhiwapurkar M K, Saran V H, Goel V K and Berg M: Influence of Whole Body Random Vibrations on Reading Activity. 44th UK Conference proceedings on Human Response to Vibration, Loughborough, 7- 9 September 2009.

Bhiwapurkar M K, Singh G, Khare D, Saran V H, Goel V K, Berg M and Mansfield N: Evaluation of drawing ability while exposing to multi axis whole body random vibrations. 44th UK Conference proceedings on Human Response to Vibration, Loughborough, 7- 9 September 2009.

Bhiwapurkar M K, Saran V H, Harsha S P, Goel V K and Berg M: Influence of Mono-axis Random Vibration on Reading Activity, Industrial Health, Vol 48, pp 675-681, 2010.

Bhiwapurkar M K, Saran V H, Harsha S P, Goel V K, Berg M and Mansfield N: Effect of magnitudes and directions (mono-axis and multi-axis) of whole body vibration exposures and subject postures on the sketching performance. Proc IMechE Journal of Rail and Rapid Transit, Vol 225, pp 71-83, January 2011.

Bhiwapurkar M K, Saran V H, Goel V K, Mansfield N and Berg M: Evaluation of human comfort using physiological indices under random whole body vibration, acoustic and thermal stressors. Submitted to International Journal of Acoustics and Vibration.

RV18. Railway vehicle dynamics and track interactions: Total regulatory acceptance for the interoperable network (DynoTrain)

Project leader	UNIFE
Scientists	From 25 partners
	(KTH: Mats Berg, Sebastian Stichel, Gustav Lönnbark, Vladislav Petrov)

Sources of funding: European Commission (FP7).

The certification of a rail vehicle in Europe represents a significant element of both vehicle cost and time to market. The objective of DynoTrain, dealing with vehicle-track interaction, is to propose an innovative methodology via a computer simulation / virtual homologation that will allow multi-system network and route approval in Europe to become a faster, cheaper and better process for all involved stakeholders. KTH is participating in three work packages: Track geometry quality (WP2), Contact geometry (WP3) and Model building and validation (WP5). There are two parallel projects to DynoTrain: Aerodynamics (AeroTrain) and Pantograph-Catenary Interaction (PantoTrain). These three projects form the TrioTrain cluster. See www.triotrain.eu for further information.

DynoTrain D5.1: State-of-the-art of railway vehicle modelling and validation, WP5 - Model building and validation, Deliverable D5.1, December 2010.

Bruni S, Vinolas J, Berg M, Polach O and Stichel S: Modelling of suspension components in a rail vehicle dynamics context, State-of-the-Art Paper of the 22nd IAVSD Symposium. Vehicle System Dynamics, Vol 49, No 7, pp 1021-1072, July 2011.

DynoTrain RP7: Air spring modelling, WP5 - Model building and validation, Report RP7, February 2012.

Lönnbark G: Characterization of track irregularities with respect to vehicle response, MSc thesis, Report TRITA AVE 2012:30, KTH, March 2012.

DynoTrain D2.1: Report on methods for description of track geometry quality, WP2 - Track geometry quality, Deliverable D2.1, June 2012.

DynoTrain D5.2: Assessment of suspension modelling and identification of input parameters, WP5 - Model building and validation, Deliverable D5.2, July 2012.

Petrov V: Algorithm for estimation of wheel-rail friction coefficient from vehicle-track forces, MSc thesis, Report TRITA AVE 2012:80, KTH, September 2012.

Mazzola L and Berg M: Secondary suspension of railway vehicles - air spring modelling: performance and critical issues, IMechE Journal of Rail and Rapid Transit, online version available from December 2012.

DynoTrain D5.5: Final report on model validation process, WP5 - Model building and validation, Deliverable D5.5, June 2013.

Petrov V, Berg M and Persson I: Estimation of wheel-rail friction for vehicle certification. Proc. of 23rd Symposium of the International Association for Vehicle System Dynamics, IAVSD. Qingdao, 19-23 August 2013.

Polach O et al.: Validation of multi-body models for simulations in authorisation of rail vehicles, 9th International Conference on Railway Bogies and Running Gears (Bogie´13), Budapest, 9-12 September 2013.

DynoTrain D3.3: Estimation of wheel-rail friction for vehicle certification, WP3 - Contact geometry, Deliverable D3.3, September 2013.

RV19. Technology opportunities and strategies toward climate-friendly transport (TOSCA)

Project leader Andreas Schäfer, University of Cambridge

Scientists (KTH) Evert Andersson, WP leader of Rail Transport

Mats Berg

Bo-Lennart Nelldal

Oskar Fröidh

Sources of funding: European Commission (FP7).

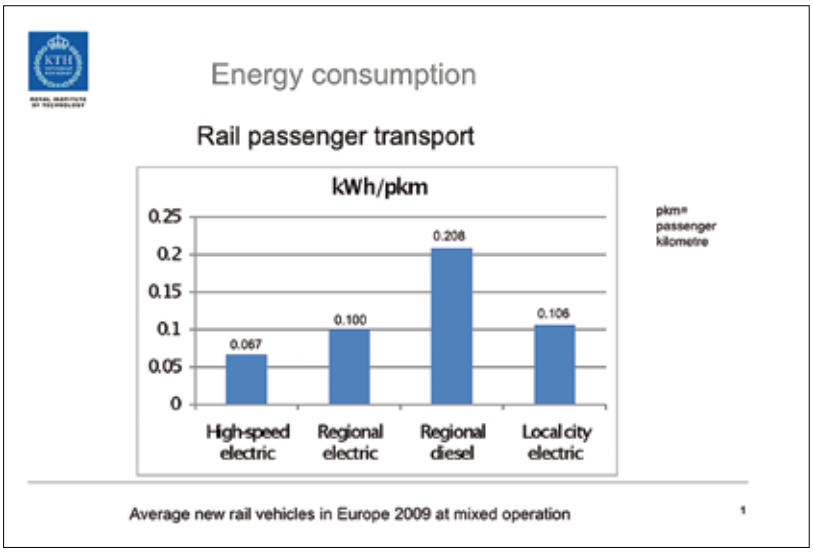
The EU has committed to reduce GHG (Green-House Gas) emissions by at least 20% based upon the 1990 level by 2020 and further reductions are expected beyond that timeframe. However, realizing this and subsequent targets may become increasingly challenging, given the past growth and future projections of transportation GHG emissions.

TOSCA was an 18-month EU Framework 7-funded project, beginning in September 2009, that aimed at investigating the potential for technologies and fuels to reduce the environmental impact of transport within the EU to 2050. The work was carried out by a consortium of seven organisations across Europe with expertise in a wide range of areas related to transportation and the environment. The activity enables the EU to obtain a better strategic perspective as to what contribution future transportation technologies and fuels could make to reduce GHG emissions.

The TOSCA project´s main objective was to identify the most promising technology and fuel pathways that could help reduce transport-related greenhouse gas emissions both over the short term (2020) and beyond (2050). To better understand the policy interventions that are necessary to push (potentially expensive) technologies and fuels into the market, a further objective was to assess the penetration of these options under different future scenario and policy conditions. These scenario outputs were then evaluated with regard to their technical feasibility, economic affordability, and overall likelihood of realisation. TOSCA operated on a total transport sector basis, with work packages devoted to road traffic, aircraft, shipping, rail traffic, infrastructure capacity and fuels, as well as scenarios and policies.

For preparation of this strategic document for the EU commission a number of European research institutes were involved:

- University of Cambridge, UK
- German Biomass Research Centre (DBFZ), Germany



Average new rail vehicles 2009 at mixed operation.

• Ecorys, The Netherlands

• Swiss Federal Institute of Technology (ETHZ), Switzerland

• Royal Institute of Technology (KTH), Sweden

• National Technical University of Athens, Greece

• Paul Scherrer Institute, Switzerland

A final report and a large number of subreports are available on www.toscaproject.org

Andersson E and Berg M: Greenhouse gas emissions from rail services – Present and future. Proceedings of Railways and Environment, Delft, 16-17 December 2010.

TOSCA D4: Rail passenger transport - Techno-economic analysis of energy and greenhouse gas reductions, WP3 report No 1, Deliverable D4, March 2011.

TOSCA D4: Rail freight transport - Techno-economic analysis of energy and greenhouse gas reductions, WP3 report No 2, Deliverable D4, March 2011.

Nelldal B-L and Andersson E: Mode shift as a measure to reduce greenhouse gas emissions, presented at Transport Research Arena conference (TRA 2012). Published by Elsevier Ltd.

RV20. Lightweight Carbody for High Speed Trains

Project leader	Peter Göransson / Sebastian Stichel
Scientists	David Wennberg
	Per Wennhage
	Sebastian Stichel

Sources of funding: KTH, Vinnova, Scania, Volvo, Saab, Bombardier, A2Zound, VTI, Trafikverket. This is a project within the Vinnova Centre for ECO2 Vehicle Design.

The carbody structure in railway vehicles is heavy in comparison to road vehicles. Weight per seat is significantly higher than in buses for example. In addition the price per kilogram is high. Reasons are partly short series and individual design for each customer. Conservative load assumptions in railway standards are another contributor. In metros and suburban trains a low mass is important due to frequent stops and in turn frequent acceleration and braking of the train. In high-speed trains with larger station intervals the energy saving potential by reduced mass is due to high mileages - up to 500000 km per year. For high speed trains, however, it is equally important to limit axle load as weight per passenger. At speeds above 250 km/h a maximum axle load of 17 tons is permitted according to European legislation. High speeds with high dynamics forces in combination with high axle loads cause severe fatigue damage on wheels and rails.

In June 2013 David Wennberg defended his PhD thesis with the topic "Multi-Functional Composite Design Concepts for Rail Vehicle Car Bodies". The main outcomes of the thesis are: A weight reduction of at least 30% regarding the carbody structure can be achieved. At the same time the wall thickness can be reduced increasing passenger comfort, and the complexity of the carbody is reduced decreasing manufacturing costs. However, it is necessary to use carbon fiber laminates to achieve sufficient stiffness.

Wennberg D: A light weight car body for high-speed trains - Literature study. Report TRITA AVE 2010:16, Centre for ECO2 Vehicle Design, KTH, 2010. ISBN 978-91-7415-591-4.

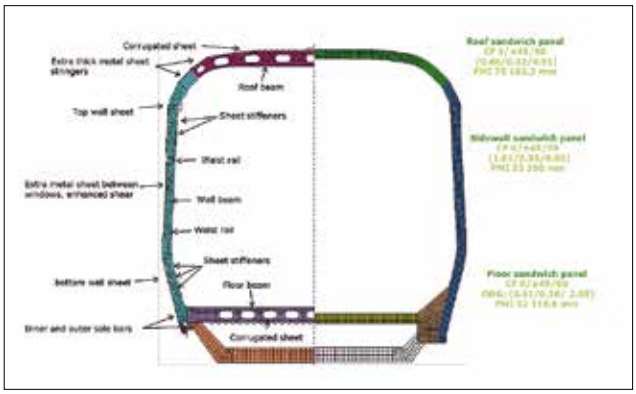
Wennberg, D., Wennhage P. and Stichel S.: Orthotropic Models of Corrugated Sheets in Finite Element Analysis, International Scholarly Research Network ISRN Mechanical Engineering Volume 2011, Article ID 979532.

Wennberg D, Stichel S and Wennhage P: Cutting the Weight of High-Speed Trains, Railway Gazette International, pp. 30-32, January 2011.

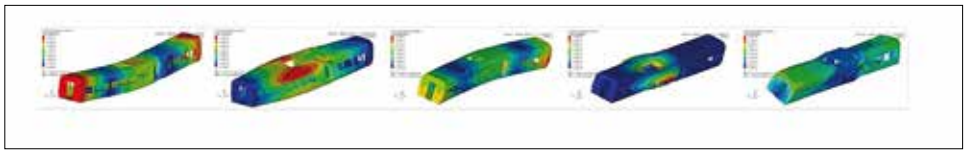
Wennberg D, Stichel S, Wennhage P. Optimisation of sandwich panels for the load carrying structure of high-speed rail vehicles. Research Publishing Services; International Journal of Aerospace and Lightweight Structures. 2012;2(1):19-40.

Wennberg D, Stichel S, Wennhage P. Benefits of weight reduction in high speed train operations. ZEV rail Glaser Annalen. 2013;137(3):77-87.

Wennberg, D. Multi-Functional Composite Design Concepts for Rail Vehicle Car Bodies. PhD thesis KTH. TRITA-AVE 2013:20, Stockholm, 2013.



Cross-section comparison between original steel body (left) and a sandwich alternative (right). Number of parts reduced by over 90% for sandwich alternative.



Typical carbody eigenmodes.

RV21. Wheel profile for freight wagons in Sweden

Project leader	Sebastian Stichel
Scientists	Carlos Casanueva
	Per-Anders Jönsson
	Sebastian Stichel

Sources of funding: KTH, Trafikverket, Green Cargo AB, Tikab, Kockums Industrier AB.

Freight wagons in Sweden use the S1002 wheel profile, developed in a benchmark back in the 70s. This profile is quite common in European countries. It is originally developed for rail inclination 1:40 and it is not a specific wheel profile for Swedish conditions. Today many operators use their own modified profile. Thus, the freight vehicle fleet has high maintenance costs due to wheel reprofiling and has some low-frequency instability related problems. Wear and rolling contact fatigue ear can be a major issue as its cost can reach up to 30M SEK per year. Some wagon types are more critical than others, with re-profiling intervals of sometimes less than 100kkm.

There is a lack of knowledge about the relationship between the dynamic behaviour of different freight vehicles and their wheel damage, and thus this is usually studied case by case. The output is usually some modifications in the vehicle design which are not applicable to all types of running gear. Thus, the purpose of this research project is to create a wheel profile suitable for freight transport in Sweden, which reduces the reprofiling costs and improves the low-frequency instability behaviour of the vehicles. This profile should especially reduce the uniform wear and the material to be removed in each reprofiling, and increase the critical speed of empty vehicles. The first reduction generates a higher running distance between reprofilings, and the second one ensures more reprofilings for each wheelset before it can no longer be used.

In the first phase of the project, the wear calculation methodology developed at the Division of Rail Vehicles at KTH is being validated for freight transport. The wear predicted by computer models will be validated with experimental results. To start with, wheel-profile measurements on Laaps wagons with Unitruck running gear that transport timber by Trätåg timber logistic company around Gävle, Borlänge and Hällefors were used for validation. It turned out that it is not possible to get good agreement between measured and simulated wheel wear with only taking straight track and curves into consideration. Only by also simulating negotiation of switches wear on certain parts of the wheel profiles observed in measurements can be achieved.

Further within the project it is intended to include a model for wear due to block brake into the simulation procedure to get even more realistic results.

Casanueva C, Jönsson P, Stichel S. Uniform Wheel Wear of a Two Axle Freight Vehicle with Friction Dampers. In: Proceedings of the First International Conference on Railway Technology: Research, Development and Maintenance. 18-20 April 2012, Las Palmas de Gran Canaria - Spain. Stirlingshire, UK: Civil-Comp Press; 2012.

Casanueva C., "Hjulprofil för godsvagnar i Sverige - Wheel profiles for freight wagons in Sweden", KTH Report, TRITA AVE 2012:74, ISSN 1651-7660.

Casanueva C., Jönsson P.-A., and Stichel S., "Use of Archard's wear law for the calculation of uniform wheel wear of high tonnage freight vehicles," in Proceedings of the 2013 Joint Rail Conference, Knoxville, Tennessee, USA.

Casanueva, C., Jönsson, P.-A., Stichel, S. Influence of Switches and crossings on Wheel Profile evolution in Freight Vehicles. Proc. of 23rd Symposium of the International Association for Vehicle System Dynamics, IAVSD. Qingdao, 19-23 August 2013.

Timber wagon from below.

Part of Unitruck running gear.

RV22. Modelling contact in the wheel-rail interface

Project leader	Roger Enblom
Scientists	Matin Shahzamanian Sichani
	Roger Enblom
	Mats Berg

Sources of funding: Trafikverket, Bombardier Transportation, SLL, Tågoperatörerna, Interfleet Technology, Vectura.

The project started in Jan 2011 with the employment of Matin Shahzamanian Sichani as Ph.D. student. The aim of this research is to arrive at a wheel-rail contact model practically applicable in the context of vehicle dynamics simulation, resting on a firm scientific foundation and answering to modern requirements regarding precision and numerical efficiency. Limitations related to traditional methods, for instance geometrical constraints, elastic identity, or half space assumption, are expected to be overcome.

The small and highly stressed contact patch is the interface to the infrastructure to be evaluated at each time step in a transient analysis. Thus the model has to be numerically efficient. Traditional methods often used in this context are Hertz' method for the normal contact and Kalker's simplified model for the tangential solution. The starting point of this project is a survey of recent pertinent research and related modelling ideas. Evaluation of approaches like multiple ellipses, discretisation by strips, various amendments to Kalker's methods, Winkler-type elastic foundations, and more is anticipated. The feasibility of modern numerical methods like boundary element discretisation should be investigated as well.

Some important steps are believed to be:

• Determination of the shape and size of the contact patch and the contact pressure distribution. With the traditional half space assumption, the normal contact becomes well defined. In case of small radii or close to conformal contact, this condition may be violated. Thus an improved model shall be able to handle non-elliptic contact areas on curved surfaces.

• Assessment of the shear stress (traction) distribution. With the traditional assumptions of quasi-identical contacting bodies, the normal and tangential problems can be solved independently. Analysis of more general contacts may however require simultaneous solution.

• Selection of numerical algorithm and implementation. With modern computer power, more sophisticated numerical methods than traditionally may be realistic. A competing consequence of the improving computer capacity is however increasing expectations on model size.

• Validation. Since the research target is some kind of simplified model it is possible to verify it by more detailed calculations like finite element analysis. Experimental verification is desirable and ultrasound measurements may be an option.

One paper has been accepted for publication and another one has been submitted. Sichani plans to present and defend his licentiate thesis in October 2013.

Sichani M Sh, Enblom R and Berg M: Comparison of non-elliptic contact models - Towards fast and accurate modelling of wheel-rail contact. Proc. of the 9th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2012), Chengdu, August 27-30, 2012. Extended version accepted for publication in the journal Wear.

Sichani M Sh: Wheel-rail contact modelling in vehicle dynamics simulation, Licentiate thesis, Report TRITA AVE 2013:47, Dep. of Aeronautical and Vehicle Engineering, KTH, Stockholm, 2013.

RV23. Make Rail The Hope for protecting Nature (MARATHON)

Project Co-ordinator	D'Appolonia
Scientists	from 16 partners

(KTH: Mats Berg, Ingemar Persson, Sebastian Stichel)

Sources of funding: European Commission (FP7).

MARATHON is a three-year project, starting in April 2011, that is investigating the possibilities of making European rail freight transport more efficient through running longer trains. The focus is put on the scenario of merging two 750 m long trains, keeping the traditional pneumatic braking system. Radio communication between the two (groups of) locomotives is developed for a reliable and safe train operation. KTH is, together with University of Rome Tor Vergata, studying the risk of train derailment at poorly synchronized braking conditions between the two halves of the long train. Tor Vergata focuses on simulation of the pneumatic brake pressure distribution in space and time, whereas KTH uses resulting brake shoe force histories to carry out 1D and 3D multibody dynamics simulations for various train braking conditions, on tangent&curved as well as gradient track. In particular derailments through buffer climbing and wheel flange climbing are studied. See www.marathon-project.eu

Marathon D3.3: Longitudinal dynamics report, WP3 - The application of technologies , report for Deliverable D3.3, November 2012.

RV24. The sustainable freight railway (SUSTRAIL)

Project Co-ordinator	Train Consortium
Scientists	from 29 partners

(KTH: Sebastian Stichel, Stefan Östlund, Mats Berg)

Sources of funding: European Commission (FP7).

The rail industry is lagging in its adoption of state of the art techniques and technologies that are gaining traction in air, shipping, and roadway transport. These include performance-based design, the use of lightweight and high performance materials, the use of structural health monitoring technologies, and the trend toward condition based maintenance. Within this context, SUSTRAIL will increase the SUSTAINABILITY, COMPETITIVENESS, and AVAILABILITY of European railway networks. The SUSTRAIL approach takes into account Methodology, Implementation Timeframe, and Means of Application. SUSTRAIL employs an integrated approach. Contributions from the different topic areas (vehicles, track, and operations) will be demonstrated on real routes. Four routes that offer geographic dispersion as well as differences in type (freight vs. passenger), mixed traffic vs. freight only routes, speed, and frequency of traffic have been made available. In specific, SUSTRAIL will conduct the following activities:

• Benchmarking to establish existing state of the art for comparison activities, including correlation of track damage levels with vehicle design parameters on three real routes in the EC (WP1);

• Duty requirements for current and future freight traffic flows. An innovative "smart embankment" concept is considered for the monitoring of the effect of high speed freight vehicles on the rail infrastructure (WP2);

• The business case for the freight vehicle-track system for higher delivered tonnage (WP5).

• Track design requirements for reduced maintenance time and whole life cost based on optimised vehicle characteristics (WP4);

• Wheelset design requirements, including consideration of unsprung mass and fatigue life (WP2 and WP3);

• Suspension design requirements, including the need for acceptable dynamic performance in tare (empty) and fully laden conditions (WP2 and WP3);

• Novel design and materials for lightweight high performance freight vehicles, including the body structure, bogies and brake systems. A new concept of lightweight will be studied using a range of advanced materials/technology (WP3);

• Recommendations for whole-system implementation, including strategies for the equitable redistribution of whole-system savings (WP5);

• A practical demonstration of potential technological solutions (WP6);

RV25. Planning tool for energy-saving loading strategy for intermodal freight trains

Project leader	Mats Berg
Scientists	Sebastian Bäckström (WSP/IVL)
	Johan Öberg
	Mats Berg

Sources of funding: Energimyndigheten.

Actions to make freight trains more efficient in terms of energy use have yet to be implemented to a large extent. This project aims at reducing the energy use for operation of intermodal trains by changing strategy for the loading of the trains. In this way the air resistance of the often heterogeneous geometry of intermodal trains can be reduced. Optimizing the loading procedure according to the lowest possible air resistance yields at least a 10% decrease in energy use. In cooperation with partners the software tool Artemis Rail has been extended to facilitate air drag optimization and in turn propose low-energy loading practices of intermodal trains. The running cycles of such trains have also been determined based on GPS measurements on some Swedish railway lines and then implemented in Artemis Rail. In addition, two intermodal freight terminals have been studied with respect to loading processes.

Padilla F: Train air resistance with special application to intermodal freight, MSc thesis, Report TRITA AVE 2012:15, KTH, 2012.

Bäckström S and Berg M: Planeringsverktyg för energibesparande lastningsstrategi av kombigodståg. Transportforum 2013, Linköping, January 2013.

Bäckström S and Berg M: Planeringsverktyg för energibesparande lastningsstrategi av kombigodståg. Slutrapport, 2013.

Structural Engineering and Bridges – SB

Professor
Raid Karoumi

The division is conducting research and education within railway engineering including bridges and tunnels. They are also responsible for co-ordination of issues concerning the railway infrastructure. More information on the research performed at the division and the publications are available on www.byv.kth.se/avd/bro.

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Professor	Lars Pettersson	lars.pettersson@byv.kth.se
Research engineer	Andreas Andersson	andreas.andersson@byv.kth.se

Graduate students:

John Leander (Lic. Eng.); Mahir Ülker-Kaustell (Lic. Eng.); Ignacio González (Lic. Eng.); Mohammed Safi (Lic. Eng.); Guangli Du (Lic. Eng.); Christoffer Johansson (Lic. Eng.); Therese Arvidsson (M.Sc.); Joakim Wallin (M.Sc.); Davide Martino (M.Sc.); Majid Solat (M.Sc.), Abbas Zangeneh (M.Sc.).

RESEARCH PROJECTS

SB 1. Loads and Load Influence on Structures

Researchers: Raid Karoumi, Gerard James

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

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. Source of Funding: KTH, Swedish Rail Administration (Banverket), Formas and KTH Railway Group.

Malm R., Predicting shear type crack initiation and growth in concrete with non-linear finite element method, doctoral thesis, 2009.

Karoumi R., Seminarium om Modern mät- och övervakningsmetodik för bedömning av befintliga broar. TRITA-BKN. Rapport 125, 2007.

Enckell M., Structural Health Monitoring of Bridges in Sweden. The 3rd International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII-3), November 14-16, 2007, Vancouver, Canada.

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
Ignacio González

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 at least 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.

Source of Funding: KTH, Swedish Transport Administration and KTH Railway Group.

González I., The validity of simplified dynamic analysis of the New Årsta Bridge's response to moving trains, Tenth International Conference on Computational Structures Technologies, Valencia, 2010.

Wiberg J., Railway bridge response to passing trains. Measurements and FE model updating, doctoral thesis, 2009.

González I., Dynamic Behaviour of the New Årsta Bridge to Moving Trains - Simplified FEM Analysis and Verifications. TRITA-BKN Master Thesis 262, 2008.

Wiberg J., Karoumi R., Monitoring dynamic behaviour of a long-span railway bridge. Journal of Structure and Infrastructure Engineering, Taylor & Francis, vol.5, 2009.

Wiberg J., Railway bridge dynamic characteristics from output only signal analysis. 2nd International Conference on Experimental Vibration Analysis for Civil Engineering Structures (EVACES´07), 24-26 October 2007, Porto, Portugal

Karoumi R, Wiberg J, Olofsson P: Monitoring traffic loads and traffic load effects on the New Arstaberg 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.

SB 5. Sustainable bridges

Researchers Raid Karoumi
Gerard James
Axel Liljencrantz

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 - Advices on the use of advanced methods. Sixth framework programme Sustainable Bridges, 2007.

Karoumi R., Jensen J.S., Casas J.R., Plos M., Cremona C., Melbourne C., Guideline for load and resistance assessment of existing European railway bridges. International Conference "Sustainable Bridges – Assessment for Future Traffic Demands and Longer Lives", Wrocław, Poland, October 10-11, 2007.

Karoumi R., Some modeling aspects in the analysis of dynamic effects of passing trains on bridges. Sustainable Bridges WP4 Workshop, Denmark, 21–22 May 2007.

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
Mahir Ülker-Kaustell
Raid Karoumi

The behaviour of integral concrete bridges and steel culvert bridges are investigated considering soil-structure interaction and dynamic effects from passing trains. The project is financed by KTH Railway Group, Trafikverket (the Swedish Transport Administration) and Viacon.

Ülker-Kaustell M., Karoumi M., Pacoste C., Simplified analysis of the dynamic soil-structure interaction of a portal frame railway bridge, Engineering structures, Vol. 32, No. 11, pp. 3692-3698, 2010.

Bayoglu E. Karoumi R., Dynamic testing of a soil-steel composite railway bridge, J. of Engineering Structures, Vol.21, 2009.

Ülker-Kaustell M., Some aspects of the dynamic soil-structure interaction of a portal frame railway bridge, Licentiate thesis, 2009.

Bayoglu E., Static and dynamic behaviour of soil-steel composite bridges obtained by field testing, doctoral thesis, 2009.

Ülker-Kaustell M., Karoumi R., Uppskattning av upplagsstyvheter och effekter av jord-bro interaktion genom dynamisk mätning - steg 1. TRITA-BKN. Rapport 123, 2008.

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
Andreas Andersson
Mahir Ülker -Kaustell

The project investigates the dynamic response of railway bridges on high-speed lines such as those for the new Bothnia line. The bridges on this line have to be designed for train speeds up to 300 km/h. Such high 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 accelerations of the bridge deck cause the ballast to lose its resistance properties to transverse forces.

Ülker-Kaustell M., Karoumi R., Influence of non-linear stiffness and damping on the train-bridge resonance of a simply supported railway bridge, Engineering structures, Vol. 41, pp. 350-355, 2012

Wiberg J., Karoumi R., Pacoste C., Statistical screening of individual and joint effect of several modelling factors on the dynamic finite element response of a railway bridge, Computers & structures, Vol. 106, pp. 91-104, 2012.

Wallin J., Leander J., Karoumi R., Strengthening of a steel railway bridge and its impact on the dynamic response to passing trains, Engineering structures, Vol. 33, No. 2, pp. 635-646, 2011.

Ulker-Kaustell M., Karoumi R., Application of the continuous wavelet transform on the free vibrations of a steel-concrete composite railway bridge, Engineering structures, Vol. 33, No. 3, pp. 911-919, 2011.

Battini J-M, Ulker-Kaustell M., A simple finite element to consider the non-linear influence of the ballast on vibrations of railway bridges, J. Engineering Structures, Vol 33, pp 2597–2602, 2011.

Ülker-Kaustell M., The dynamic properties of two concrete railway bridges during the testing of Gröna Tåget. TRITA-BKN. Rapport 117, 2007.

Lorieux L., Analysis of train-induced vibrations on a single-span composite bridge. Master thesis, 2008.

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

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.

Railway bridge across road 890 at Rössjö, Botnia line. Measurement during tests with Gröna Tåget.

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

Researchers Raid Karoumi
Axel Liljencrantz

This is a project financed by the Swedish rail administration (Banverket) and KTH.

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

Karoumi R., Fredrik C., Liljencrantz A., Assessment of actual traffic loads using B-WIM. Background document SB D4.3.2, Sixth framework programme Sustainable Bridges, 2007.

Liljencrantz A, Karoumi R, Twim – a MATLAB toolbox for real-time evaluation and monitoring of traffic loads on railway bridges, J. of Structures and Infrastructure Engineering, vol.5, 2009.

Liljencrantz A, Karoumi R, Olofsson P, Implementing Bridge Weigh-in-Motion for railway traffic, Computers and Structures, vol.85, 2007.

Liljencrantz A., Monitoring railway traffic loads using Bridge Weight-in-Motion, Licentiate thesis, 2007.

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.

SB 10. Enhanced Fatigue Evaluation of Old Steel Railway Bridges

Researchers Raid Karoumi
John Leander
Andreas Andersson

This project is financed by Trafikverket (the Swedish Transport Administration) and the KTH Railway Group. The project started in 2008 and will continue until 2013. The project's main objective is to study the remaining fatigue life of railway bridges by response monitoring combined with advanced analysis methods. The project focuses mainly on the Söderström Bridge in central Stockholm which is one of Sweden's most important railway bridges.

Andersson, A., Leander, J., Karoumi, R., Extending the fatigue service life of a railway bridge by local approaches. International IABSE Conference, Assessment, Upgrading and Refurbishment of Infrastructures, Rotterdam May 6 - 8, 2013.

Leander, J., Karoumi, R., Rate of convergence of measured stress range spectra. Proceedings of the Sixth International Conference on Bridge Maintenance, Safety and Management (IABMAS), 2012.

Leander, J., Karoumi, R., Quality Assurance of Measured Response Intended for Fatigue Life Prediction. Journal of Bridge Engineering 17(4), 2012.

Leander, J., Andersson, A., Järnvägsbro under bevakning. Samhällsbyggaren (3), 2011.

Leander, J., Improving a bridge fatigue life prediction by monitoring. Licentiate thesis, KTH Royal Institute of Technology, TRITA-BKN. Bulletin 106, 2010..

Leander, J., Andersson, A., Karoumi, R., Monitoring and enhanced fatigue evaluation of a steel railway bridge. Engineering structures 32(3), 2010.

Leander, J., Andersson, A., Karoumi, R., Enhanced Assessment of the Remaining Service Life of a Steel Railway Bridge. Key Engineering Materials, Damage Assessment of Structures VIII, 2009.

Andersson A., Utmattningsanalys av järnvägsbroar, en fallstudie av stålbroarna mellan Stockholm Central och Söder Mälarstrand, baserat på teoretiska analyser och töjningsmätningar. Licentiate thesis, KTH Royal Institute of Technology, TRITA-BKN. Bulletin 97, 2009.

Leander J., Bro över Söderström, mätning och utvärdering m.a.p. utmattning. Report, KTH Royal Institute of Technology, TRITA-BKN. Rapport 126, 2008.

SB 11. Development and Implementation of Monitoring Systems for Increased Safety and Improved Operation and Maintenance of Railway Bridges

Researchers Raid Karoumi
Ignacio González

This project is financed by Trafikverket (the Swedish Transport Administration) and KTH. The project started in 2009 and will continue until 2012. The project's main objective is to investigate available structural health monitoring techniques and to develop a bridge monitoring system which can assist railway owners in the operation and maintenance processes for bridges.

The project has produced an extensive state-of-the-art literature review on the latest development in Structural Health Monitoring relevant to bridge structures. Monitoring systems have been developed, implemented and tested on the High Coast suspension bridge and the Söderström railway bridge. Emphasis has been placed on monitoring the traffic loads acting on bridges as these are the main contributor to wear and damage in bridges. In the next step, the feasibility of wireless monitoring techniques and their applicability to bridges will be investigated. The project has so far resulted in the following publications:

Gonzalez, I., Study and Application of Modern Bridge Monitoring Techniques. Licentiate Thesis. KTH, Royal Institute of Technology. Stockholm, 2011.

González, I., Traffic monitoring using a deployed Structural Health Monitoring System. Accepted for publication in ICE Bridge Engineering.

Shu, J., Karoumi, R., Gonzalez, I., The application of a damage detection method using Artificial Neural Network and train-induced vibrations on a simplified railway bridges model. Engineering Structures, 52, pp 408–421, 2013.

Railway bridge at "Döda fallet" at road 87, Österede.

SB 12. Development of Methodology for LCC and LCA of Railway Bridges

Researchers Raid Karoumi
Mohammed Safi
Guangli Du

This project is financed by Trafikverket (the Swedish Transport Administration) and KTH. The project started in 2009 and will continue until 2013. The project is focused on 1) the implementation of LCC and LCA for railway bridges via the case studies of actual performed construction, maintenance and repairs, and end of life scenarios; 2) the development of LCC and LCA calculation tools for bridges; 3) the development of guidelines for LCC and LCA evaluation of railway bridges.

The project aims at enhancing the bridge investment and management decisions by Integrating the LCC and LCA with the decision making process. This will ensure that the society's needs are optimally met and assist in providing more sustainable bridges. Two simplified standalone computer tools were developed for this propose supported with real case studies and implementation examples.

Safi M., Sundquist H., Racutanu G., Life-Cycle Costing Integration with Bridge Management Systems, J. ICE-Bridge Engineering. (Submitted on 16 April 2011)

Safi M., Sundquist H., Karoumi R., Racutanu G., LCC applications for bridges & Integration with BMSs- case study whether to repair or to replace a bridge, J. ASCE-Bridge Engineering. (To be submitted 2011)

Safi M., Sundquist H., Karoumi R., Guangli Du., Integrated Bridge Life Cycle-Cost Approach for Extended Bridge Sustainability, J. Structure and Infrastructure Engineering, Maintenance, Management, Life-Cycle Design & Performance. (To be submitted 2011)

Racutanu G., Safi M., Sundquist H., LCC applications for bridges & Integration with BaTMan. Technical Report for Trafickverket, Royal Institute of Technology. (to be submitted 2011)

Du, G., Towards sustainable construction: life cycle assessment of railway bridges, Licentiate thesis in Division of Structural Engineering and Bridges, KTH Royal Institute of Technology, Stockholm, 2012.

Du, G., and Karoumi, R., Life cycle assessment of a railway bridge: comparison of two superstructure designs, Structure and Infrastructure Engineering, accepted for publication in 2012.

Du, G, and Karoumi R., Life cycle assessment framework for railway bridges: literature survey and critical issues, Structure and Infrastructure Engineering, accepted for publication in 2012.

Thirbault V., Du G., Karoumi R., Design of railway bridges considering LCA, Journal of ICE Bridge Engineering, accepted for publication in 2012.

Rossi, B., Lukic I., Iqbal N., Du G, Cregg D., Borg R. P., Haler P., Life cycle impacts assessment of steel, composite, concrete and wooden columns, COST Action C25: Proceedings of the international conference sustainability of constructions-towards a better built Environment. Innsbruck, Austria, 2011.

Du G., and Karoumi R., Environmental life cycle assessment comparison between two bridge types: reinforced concrete bridge and steel composite bridge, The Third International Conference on Sustainable Construction Materials and Technologies (SCMT3), Kyoto, Japan, 2013.

SB 13. Efficient Assessment Methods of the Dynamic Response of Existing Railway Bridges to High-speed Trains

Researchers Raid Karoumi
Costin Pacoste
Andreas Andersson
Christoffer Johansson

This project is financed by Trafikverket (the Swedish Transport Administration) and KTH. The project started in 2010 and will continue until 2014. The purpose with this project is to develop simplified and efficient analysis tools that will allow the decision makers (Railway administration for instance) to quickly analyse a large number of bridges and identify the ones that are likely to exhibit unacceptable acceleration levels if subjected to high speed train passages. The bridges in this latter category can then be subjected to more refined analyses partly based on the probabilistic methods that will be developed within the project.

The project has resulted in the following publications:

Johansson, C., Pacoste, C., and Karoumi, R., Closed-form solution for the mode superposition analysis of the vibration in multi-span beam bridges caused by concentrated moving loads. Computers and Structures, 119, pp 85–94, 2013..

Johansson, C., Pacoste, C., and Karoumi, R., Development of design curves for preliminary dynamic assessment of railway bridges to higher speeds, accepted by International Journal of Railway Technology, 2013.

Ní Nualláin, N.Á., Johansson, C., Andersson, A., Karoumi, R., and Pacoste, C., Applicability of probabilistic methods of assessing a network of bridges, submitted to Engineering Structures in Aug 2012.

Johansson, C., Ní Nualláin, N.Á., Andersson, A., and Pacoste, C., Probabilistic dynamic analysis of existing railway bridges for high-speed traffic, submitted to Engineering Structures in Oct 2012.

KTH-Brobyggnad rapport, Höghastighetsprojekt – Bro Delrapport 1, Befintliga krav och erfarenheter samt parameterstudier avseende dimensionering av järnvägsbroar för farter över 200 km/h, KTH Brobyggnad, TRITA-BKN Rapport 139, 2010.

SB14. Train-track-bridge interaction

Researchers Raid Karoumi
Therese Arvidsson

The project is financed by KTH Railway Group. The aim is to develop models that consider the influence of train-track-bridge dynamic interaction. Guidelines and recommendations are to be developed for how to model the train and the track for different types of bridges and different span lengths. The project investigates also how future heavy freight trains influence the bridges. One of the goals is to determine which bridge types and span lengths that are particularly sensitive to future heavy freight trains. The project started in 2011 and a licentiate ¬ thesis will be presented in early spring 2014.

The project has resulted in the following publications:

Arvidsson T., Karoumi R., Pacoste C., Statistical screening of modelling alternatives in train-bridge interaction systems, submitted to Engineering Structures, 2013.

Arvidsson T., Karoumi R., Pacoste C., Train-bridge interaction - a review and discussion of key model parameters, To be submitted in 2013.

Electric Power Engineering – EP

The Department for Electrical Energy Conversion 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 on railway power supply systems is conducted together with the Department for Electric Power Systems.

Professor Stefan Östlund

RESEARCH PROJECTS

EP 1. New converter topologies for electric railway traction

Researchers Stefan Östlund
stefan.ostlund@ee.kth.se
Tommy Kjellqvist
Lars Abrahamsson
lars.abrahamsson@ee.kth.se
Staffan Norrga, norrga@kth.se

Period: Stage 1 00-05, Stage 2 05-11

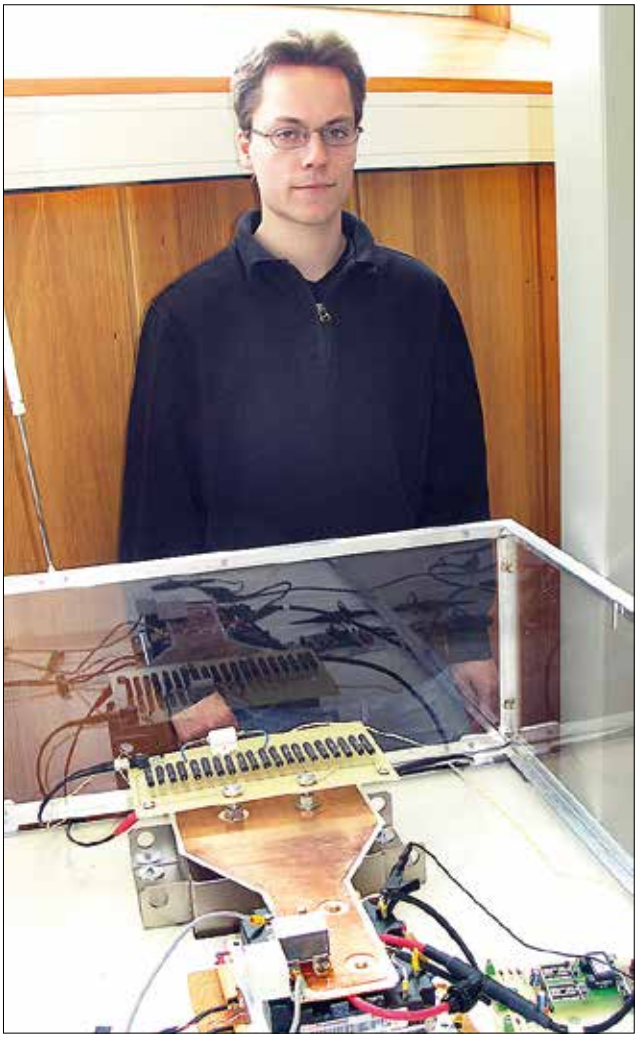
Source of funding/partners: Banverket/Trafikverket

PhD degrees awarded:

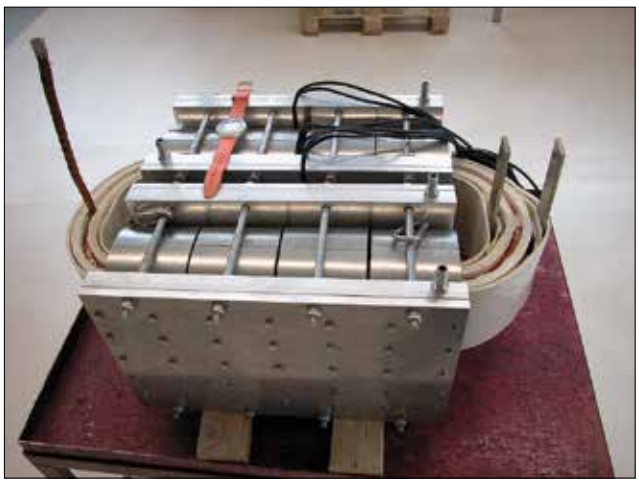
Staffan Norrga "On Soft-Switching" Isolated AC/DC Converters without Auxiliary Circuit", May 2005

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

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



PhD Tommy Kjellqvist, Researcher in EP1.



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

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 consisted of four parts, design of the transformer; characterization of soft-switched IGBTs for use in a snubbered VSC; Design of a high-voltage cyclo-converter including gate-drives for series-connection of devices and finally system issues and applications.

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

Kjellqvist T, Norrga S, Östlund S and Ilves K: 'Evaluation of a Medium Frequency Transformer in a Line Side Conversion System, Proceedings of the 13th European Conference on Power Electronics and Applications September 2009, Aalborg, Denmark

Abrahamsson, L, Kjellqvist, T and Östlund, S: High-voltage DC-feeder solution for electric railways. IET Power Electronics, 5(9), 1776-1784, 2012

Laury, J, Abrahamsson, L and Östlund, S: OPF for an HVDC Feeder Solution for Railway Power Supply Systems. Paper presented at The 13th International Conference on Design and Operation in Railway Engineering (COMPRAIL 2012), The New Forest, UK, 2012

Abrahamsson, L, Östlund, S, Schütte, T and Söder, L: An electromechanical moving load fixed node position and fixed node number railway power supply systems optimization model. Transportation Research Part C, 30, 23-40, 2013

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

Researchers Stefan Östlund PhD
stefan.ostlund@ee.kth.se

Mattias Skoglund MSc
mattias.skoglund@tfk.se

Peter Bark, Ph.D
peter.bark@tfk.se

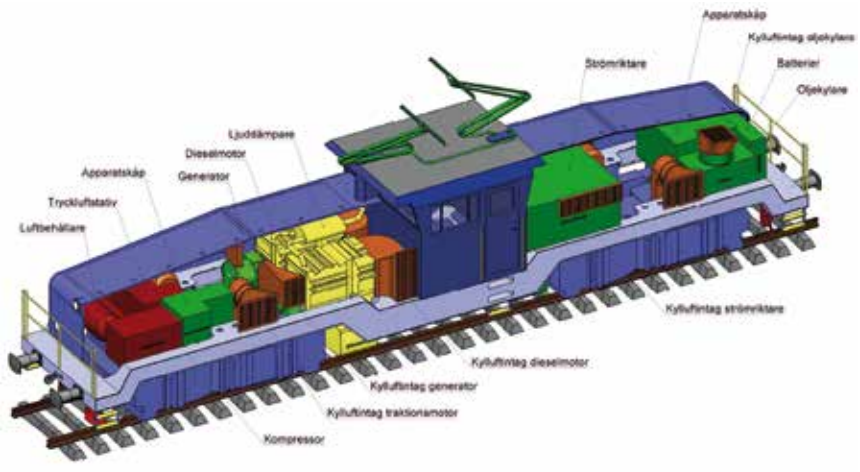
Source of funding/partners:
Banverket/Bombardier Transportation

Period: Stage 1 06-09, Stage 2 06 – 11..

The project was carried out in cooperation with TFK. It consisted of two parts. The objective of the first part was 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 and its impact on the operation regarding for instance energy consumption, logistics and emissions. The objective of the second part was 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

EP 3. System aspects of Permanent magnet traction motors

Researcher: Juliette Soulard Ph.D
juliette.soulard@ee.kth.se

Source of funding/partners: Bombardier Transportation

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.

PhD Juliette Soulard, Researcher in EP 3

EP 4. Train Information Management and Monitoring (TIMM)

Researchers Stefan Östlund KTH
stefan.ostlund@ee.kth.se
Mats Berg KTH, mabe@kth.se
Fredrik Carlsson KTH
Martin Bohlin SICS
Anders Holst SICS
Martin Aronsson SICS

Source of funding/industrial partners: Vinnova, Bombardier Transportation, SKF, Tågoperatörerna

Period 2006-2007

The project was carried out in cooperation with the 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 dealt 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. Our part has been focused on monitoring of the the current collection.

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

Researchers

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

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

Period 2008-2011

The DUST project was a follow-up of the TIMM project focusing on issues regarding Condition based maintenance in train operations, and its consequences for production planning and control. The focus has been 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 was to develop methods that link 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.

Aronsson M, Bohlin M. Doganay K, Holst A, Kjellqvist T and Östlund S: 'An Integrated Adaptive Maintenance Concept' Proceesinds of International Conference on Condition Monitoring and Diagnosis, Sept. 6–11, 2010, Toyosu, Tokyo

EP 6. Railway Power Supplies with new converter and system topologies

Researchers:

Staffan Norrga
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Lars Abrahamsson
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Period: 2013-2017

Source of funding/partners: Railway Group

The latest stage in the development of converter stations for railway feeding is the introduction of modular multilevel converters. For railway feeding purposes converters with direct ac/ac conversion capability will probably be used. These converters offer many benefits such as reduced losses, and increased modularity, which can improve reliability through redundancy. Also, the possibility to design the converter with high-voltage output so that it can be connected to the catenary network without a transformer reduces cost and losses. However, these converters have complex and highly non-linear dynamics which present challenges for their design, control and operation. This can lead to uncontrolled resonances and other unwanted phenomena. The objectives of the project are to increase reliability and improve hardware. To achieve this, an important subtask will be the creation of proper analytical models of the system dynamics. Based on these, control schemes and design methodologies can be developed.

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 the forces transmitted through the contact. A handbook published by Woodhead Publisher Limited and entitled Wheel/rail interface handbook has been edited by Roger Lewis Sheffield University UK and Ulf Olofsson Railway Group, KTH.

Professor Ulf Olofsson

RESEARCH PROJECTS

ME 1. Track-vehicle interaction (SAMBA 6)–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 ail 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 were studied with special emphasis on the transition between mild and severe wear. Jon Sundh Defended his PhD thesis on the 11th of December 2009.

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

Sundh J, Olofsson U, Olander L, and Jansson A., Wear rate testing inrelation 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. On wear transitions in the wheel rail contact, Doctoral thesis Department of Machine Design, KTH (2009).

ME 2. Adhesion between railway wheel and rail

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

Sources of funding: Banverket, SL 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 adhesion models for the railway wheel rail contact including contaminants.

Publications since 2008-

S. Lewis, U. Olofsson, R. Lewis, J. Cotter, A study on top of rail friction – Influence of temperature, humidity, biological material and top of rail friction modifiers, 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, Firenze, Italy, September 15-18, 2009.

U. Olofsson, Adhesion and Friction Modification at the Wheel–Rail Contact, in Handbook of the wheel rail interface, Ed. R. Lewis and U. Olofsson.

U. Olofsson, A study of top of rail contaminants, Nordtrib 10 Storforsen Sweden, June 10 – 14 2010.

S. Lewis, R. Lewis, Y. Zhu , S. Abbasi,U. Olofsson, The Modification of a Slip Resistance Meter for Measurement of Railhead Adhesion, IHHA-2011, Calgary Canada June 19-22 2011. Best paper award IHHA.

R. Lewis, S. Lewis, U. Olofsson, D. T. Eadie, J. Cotter, X. Lu, Effect of Humidity, Temperature and Railhead Contamination on the Performance of Friction Modifiers: Pin-on-Disk Study, IHHA-2011, Calgary Canada June 19-22 2011.

Y. Zhu, A Söderberg, U. Olofsson Adhesion in wheel-rail contact: NSJ 2010, September 14-15 2010, Stockholm, Sweden

Y. Zhu, A Söderberg, U. Olofsson Adhesion Modeling in the Wheel-rail Contact under Wet Condition using Measured 3D Surfaces: 22nd international symposium on dynamics of vehicles on roads and tracks 2011, Manchester, U.K

Y. Zhu, U. Olofsson, "An adhesion model for wheel–rail contact at the micro level using measured 3d surfaces", Submitted to 9th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems 2012, Aug 27-30, Chengdu, China

U Olofsson, Y Zhu, S Löfving, J Casselgren, L Mayer, R Nilsson, "An optical sensor for the identification of low adhesion in the wheel rail contact", Submitted to 9th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems 2012, Aug 27-30, Chengdu, China

Y. Zhu, U. Olofsson, R. Nilsson: "A field test study of leaf contamination on the rail head surfaces", the first International conference on Railway Technology: Research, Development and Maintenance, Apr 18-20, 2012, Las Palmas, Spain

Y. Zhu, U. Olofsson, A.Söderberg: "Adhesion modeling in the wheel-rail contact under dry and lubricated conditions using measured 3D surfaces", Tribology International 61 (2013) 1-10

Y. Zhu, U. Olofsson, K. Persson: "Investigation of factors influencing wheel-rail adhesion using a mini traction machine", Wear 292-293 (2012) 218-231

Y. Zhu, U. Olofsson, R. Nilsson: "A field test study of leaf contamination on the rail head surfaces", Article in press, IMechE Part F: J. of Rail and Rapid Transit

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U. Olofsson, Y. Zhu, S. Löfving, J. Casselgren, L. Mayer, R. Nilsson, "An optical sensor for the identification of low adhesion in the wheel rail contact", Submitted to International Journal of Railway Technology

S.R. Lewis, R. Lewis, & U. Olofsson, "An alternative method for the assessment of railhead traction", Wear, vol. 271, no. 1-2, pp. 62-70 (2011).

Y. Zhu, Adhesion in the wheel-rail contact under contaminated conditions, licentiate thesis, Department of Machine Design KTH December 2011, TRITA-MMK 2011:15.

R. Lewis, S. Lewis, Y. Zhu, S. Abbasi, U. Olofsson, "The Modification of a Slip Resistance Meter for Measurement of Railhead Adhesion", article in press IMechE Part F: J. Rail and Rapid Transit

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.

Publications since 2008-

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U. Olofsson,, A study of airborne wear particles generated from the train traffic – a pin on disc simulation of block brake materials, 8th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, Firenze, Italy, September 15-18, 2009, also Wear (2011) 271(1–2), 86–91.

S. Abbasi, J. Wahlstrom, L. Olander, C. Larsson, U. Olofsson, U. Sellgren, A study of airborne wear particles generated from railway organic brake pads and brake discs, June 8-11 Nordtrib 2010. Accepted for publication in WEAR.

S. Abbasi, J. Wahlstrom, L. Olander, C. Larsson, U. Olofsson, U. Sellgren A field investigation of morphology and chemical composition of airborne particles in rail transport" ;NSJ2010, 14-15th September 2010

S. Abbasi, J. Wahlstrom, L. Olander, C. Larsson, U. Olofsson, U. Sellgren A proposed methodology for predicting railway brake pad wear with thermomechanical finite-element simulations ; Nordic 2010 NAFEMS, 26-27th October 2010

S. Abbasi, J. Wahlstrom, L. Olander, C. Larsson, U. Olofsson, U. Sellgren A field investigation of the size, morphology and chemical composition of airborne particles in rail transport; RAILWAYS & ENVIRONMENT International conference 16th December 2010

U. Olofsson A study of airborne wear particles generated from the train traffic-Block braking simulation in a pin-on-disc machine", Wear, vol. 271, no. 1-2, pp. 86-91 (2011).

S. Abbasi, L. Olander, C. Larsson, A. Jansson, U. Olofsson, U. Sellgren, A field test study of airborne wear particles from a running regional train, IMechE, Part F: Journal of Rail and Rapid Transit, vol. 226 (2012) 18-29.

S. Abbasi, A. Jansson, L. Olander, U. Olofsson, U. Sellgren, A pin-on-disc study of the rate of airborne wear particles emission from railway braking materials', Wear vol. 284-285 (2012) 18-29.

S. Abbasi, U. Sellgren, A. Jansson, U. Olofsson, Particle emissions from rail traffic: A literature review, proceeding Critical Reviews un Environmental Science and Technology, In press (2012)

S. Abbasi, Characterization of airborne particles from rail traffic, licentiate thesis, Department of Machine Design KTH August 2011, TRITA-MMK 2011:11.

S. Abbasi, J. Wahlstrom, L. Olander, C. Larsson, U. Olofsson, U. Sellgren, A study of airborne wear particles generated from railway organic brake pads and brake discs, WEAR vol. 273(2011) 93-99

S. Abbasi, U. Olofsson, U. Sellgren, A Review of Particle Emissions from Rail Vehicles, Railway Technology: Research, Development and Maintenance, 18-20 April, Spain (2012)

T. Vernersson, R. Lundén, S. Abbasi, U. Olofsson, Wear of Railway brake block materials at elevated temperatures; pin-on-disc experiments, Euro brake, April 16-18, Germany 2012

S. Abbasi, U. Olofsson, U. Sellgren, A study of friction modifiers on airborne wear particles from wheel-rail contact, Nordtrib 2012, June 12-15, Norway 2012

S. Abbasi, U. Sellgren, U, Olofsson Experiences of measuring airborne particles from braking materials and wheel-rail contact, Contact mechanics 2012, August 27-30, China

S. Abbasi, S. Teimourimanesh, T. Vernersson, U. Sellgren, U, Olofsson, R. Lundén Temperature and thermo-elastic instability of Tread braking friction materials, Contact mechanics 2012, August 27-30, China

ME4. Block brakes during winter conditions

Project leader: Ulf Olofsson
Research engineer Peter Carlsson

Source of founding commission from SL

The main purpose is to develop measuring methodology to predict how snow and ice affect block brakes braking performance. In addition methods to increase the braking performance during winter conditions is developed in the project.

ME5. Quit track

Project leader: Ulf Olofsson
Senior lecturer Stefan Björklund
Researcher Ellen Bergseth
Research engineer Peter Carlsson

Source of founding EU project

The noise level of train traffic is affected by among many phenomena the surface topography of the contacting bodies. KTH Machine Design participates in the Euopean project Quit track with their competence in surface topography and contact mechanic modeling of the wheel rail contact. The main purpose of their part of the project is to develop models for the surface topography change of wheel and rail running on straight track.

Traffic and Logistics – ToL

The Railway Traffic Planning Group is the group that works with railway traffic planning. It belongs to the Department of Transport Science at the School of Architecture and the Built Environment at KTH. Research is conducted in the areas of freight transportation and passenger transportation, and capacity analysis and simulation. The Railway Traffic Planning Group has specialist competence in traffic planning, railway operation and economics, forecasting models and customer valuations, market analysis for passenger and freight traffic, simulation models for track capacity, and infrastructure planning.

The Railway Traffic Planning Group currently has 12 members. The group was formed in 1991 and has since its inception been led by adjunct professor Bo-Lennart Nelldal. In August 2013 PhD Oskar Fröidh will take over leadership of the Railway Traffic Planning Group.

Professor Bo-Lennart Nelldal

PhD Oskar Fröidh

RESEARCH PROJECTS

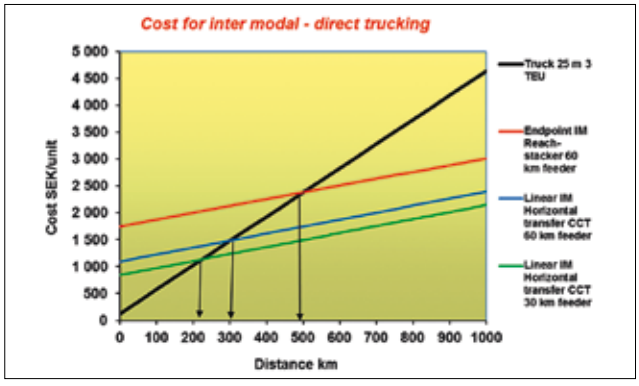
FREIGHT AND LOGISTICS

ToL 1. Model for supply and costs for freight transport by rail

Researchers: Bo-Lennart Nelldal
Behzad Kordnejad
Fredrik Hagelin

Source of funding: Swedish National Transport Administration (Trafikverket) and EU. Duration: 1998-2013

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, changes in cost structure and get input data for forecast-models and calculations of new transport-systems. A cost model for the railway was presented in a doctoral thesis in 2009 which consists of three levels: Infrastructure, rail operation and freight flows.

The models have subsequently been developed further in other projects, i.e. models for calculation of intermodal transportation, terminal costs and truck costs. A model for evaluation of different wagon types and train configurations has also been developed and used in the Green Freight Train 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

Utvärdering av intermodala transportkedjor – Kostnadsmodeller. Robert Sommar 2010-04-12.

Study on railway business for VEL-wagon and target costs. Armando Carrillo Zanuy, Bo-Lennart Nelldal, Hans Boysen. D3.1 VEL-wagon report 30.4.2012.

ToL 2. Regional Intermodal Transport Systems – Analysis and Case Study

Researcher: Bezadh Kordnejad

Sources of funding: Swedish National Traffic Administration (Trafikverket) and KTH Railway Group. Duration 2010-2015.

The railway's market share for transportation in major metropolitan areas has steadily declined at the same time as the total need for transportation has increased. In order to obtain a transport system that is sustainable in the long term a larger proportion of intermodal transport solutions is desirable, where the railways play a bigger role.

Conventional rail freight is commonly competitive on long distances and in endpoint relations between two nodes. An intermodal liner train, however, makes stops along the route for loading and unloading. In regional or interregional relations, the concept has the potential to reduce drayage by truck to and from intermodal terminals and to make rail freight competitive also over medium and short distances.

The main aim of this thesis project has been to analyse under what conditions a combined transport system based on the railway can be implemented in the Stockholm-Mälaren region. Based on a case study for a shipper distributing daily consumables in the region, the feasibility of creating a regional rail freight transport system has been evaluated.

A licentiate thesis was published in 2013 and the project is planned to continue to a doctoral thesis in 2015.

Regional Intermodal Transport Systems – Analysis and Case Study in the Stockholm-Mälaren region. Behzad Kordnejad, Licentiate Thesis, KTH 2013, KTH TRITA-TSC-RR 13-006.

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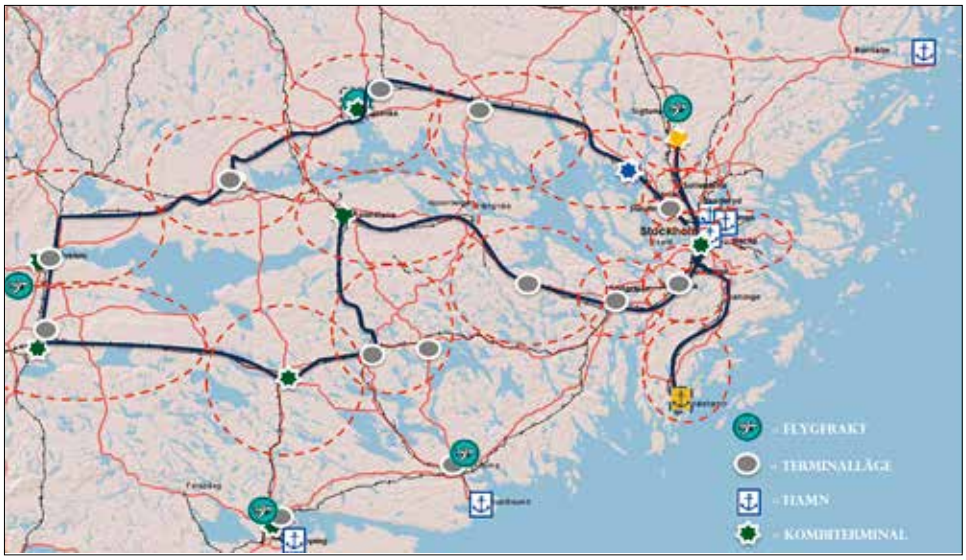
Linjetåg för småskalig kombitrafik – Analys av marknad och produktionssystem och förslag till pilotprojekt, Bo-Lennart Nelldal (red), Gerhard Troche, Jakob Wajsman och Robert Sommar, rapport 2011-09-30



ToL 3. Efficient feeder transports by rail

Researcher: Fredrik Hagelin

Source of funding: Swedish National Traffic Administration (Trafikverket). Duration 2013-2014.

Feeder transportation is often cost-intensive and constitutes a large portion of the cost of the entire transportation assignment even if the distance is short compared to the total transportation distance. This has led to the closure of much of the feeder transportation system and freight being shifted to road haulage not only over the shorter feeder leg but all the way.

The purpose of this project is to develop cost models for feeder transportation and to evaluate existing feeder methods and then to develop new conceptual ideas for feeder transportation and evaluate them with the aim of making feeder transportation by rail more efficient.

There is also a project about wagon-load traffic in competition, analysing the organization of marshalling in a deregulated market.

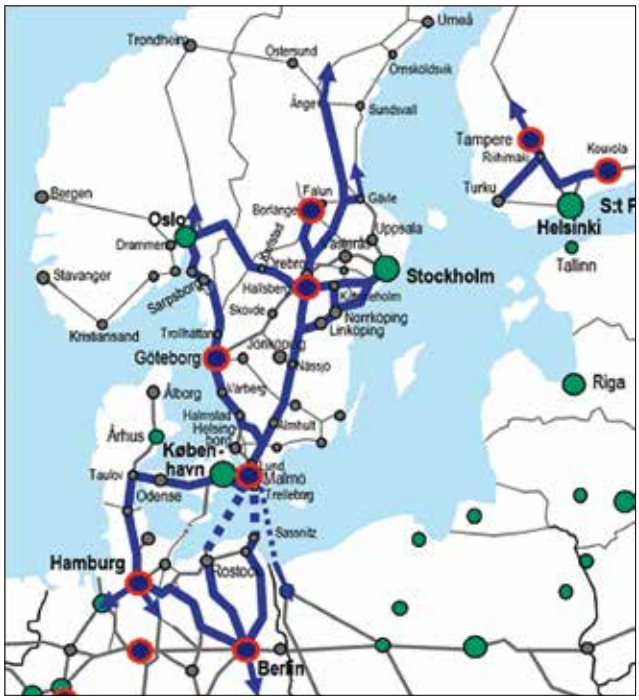
ToL 4. SCANDRIA – Scandinavian-Adriatic Corridor for Growth and Innovation

Researchers: Bo-Lennart Nelldal
Hans Boysen

Source of funding: European Union. Duration: 2010–2012.

SCANDRIA - Scandinavian-Adriatic Corridor for Growth and Innovation - aims to improve transport possibilities and increase the exchange between Scandinavia and northern Germany in a manner that is sustainable in the long term. Scandria is a corridor stretching from Scandinavia via Germany and down to the Adriatic. Scandria is a collaborative project with 19 parties from Germany, Sweden, Denmark, Norway and Finland participating.

KTH Railway Group is contributing with analyses of rail transport corridors. These include operational and infrastructure standards in order to identify bottlenecks and propose measures to establish a corridor with a common standard that is sufficiently high to be able to provide an alternative to road transport. Alternative routes with ferries and fixed connections have been analysed. On the passenger traffic side, an analysis is also included of how passenger traffic can be improved, among other things by means of a high-speed network via the fixed links on the Fehmarn Belt that are due for completion in 2021.



German–Scandinavian railway services - further development assured. Hans Boysen, Baltic Transport Journal, 6/2010

General model of railway transportation capacity. Hans Boysen 13th International Conference on Design and Operation in Railway Engineering (Comprail), New Forest, 2012.

Scandria Railway Corridor Performance. Baltic Sea Region Project 26, Scandinavian Adriatic Corridor for Growth and Innovation. Bo-Lennart Nelldal and Hans Boysen. Scandria report 2012-09-07

Developments in railway freight transportation between Scandinavia and Germany. Hans Boysen, 6th South North Axis (Sonora) University Think Tank Conference, České Budějovice, 2010

The Fran-Scan hi-cube intermodal corridor (G2, P/C 450). Hans Boysen, 7th South North Axis (Sonora) University Think Tank Conference, Trieste, 2011

ToL 5. Bothnian Green Logistic Corridor (BGLC)

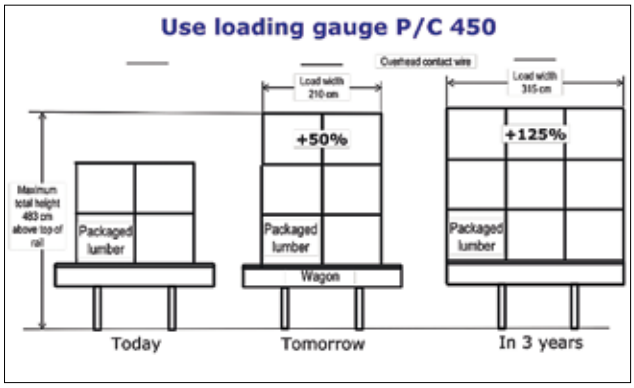
Researchers: Fredrik Hagelin
Hans Boysen
Bo-Lennart Nelldal

Source of funding: European Union. Duration: 2011–2014.

The overall objective of the proposed Bothnian Corridor project is to increase integration between northern Scandinavia and Barents, with its vast natural resources and increasing industrial production, and the industrial chain and end markets in the Baltic Sea Region and central Europe. This will be done by improved planning, utilization of the infrastructure in the Bothnian Corridor, practising green corridor concepts, promoting smooth intermodal solutions and increasing collaboration between stakeholders in society, industry, transportation and logistics. Members are regions, transport administrations, seaports and universities of Finland, Germany, Poland, Norway and Sweden, in total 29 organisations.

Quicker meets, heavier loads and faster empties – effects on transportation capacity and cycle time. Hans Boysen, 10th International Heavy Haul Conference (IHHA), New Delhi 2013.

Øresund and Fehmarnbelt high-capacity rail corridor standards. Hans Boysen, 12th International Railway Engineering Conference, London 2013.



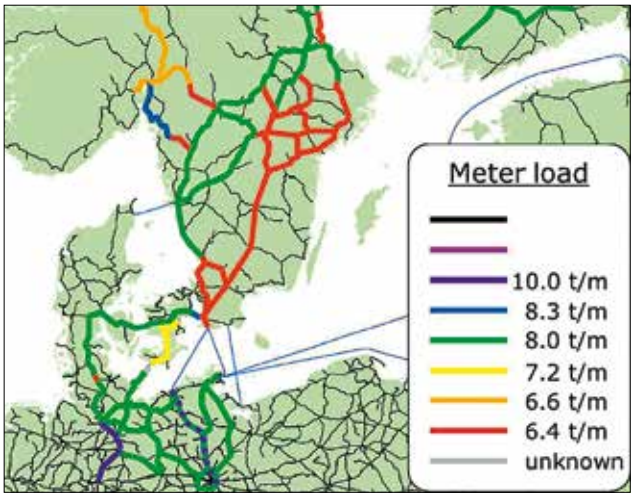
ToL 6. COINCO north – Border problems for rail transportation

Researchers; Hans Boysen
Bo-Lennart Nelldal

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2013-2014

Train traffic in Sweden has seen very positive development but cross-border traffic has not developed as positively. The railway's market share of international transportation is only half that of domestic transportation despite long distances and substantial volumes. This means that on the Oslo-Gothenburg-Copenhagen route, the railway has a very small share of the market. One reason for this is problems at border crossings. In addition to technical problems, for example different loading gauges and axle loads, administrative problems can also constitute an obstacle. These may for example be in the form of different brake regulations, vehicles needing to be approved to operate in another country, etc.

The aim of the project is to describe any problems that exist that can be related to freight transportation over



national borders, primarily between Sweden and Norway and Denmark. The problems can be both technical and administrative. Proposals for how the problems can be reduced or eliminated will also be drawn up as far as possible.

ToL 7. The VEL wagon – efficient and longer wagons for future freight transportation

Researchers: Hans Boysen
Bo-Lennart Nelldal

Source of funding: EU. Duration: 2011–2012.

VEL stands for Versatile, Efficient and Longer Wagon for European Transportation and aims to develop more efficient freight wagons for future freight transportation in Europe. The aim is to strengthen the railway's competitiveness compared to truck traffic. The project is funded by the EU and is a collaborative project between TU-Berlin, who was the project leader, KTH and the University of Žilina (UNIZA), and wagon manufacturer Tatravagónka a.s. Poprad (TVP) in Slovakia.

One of the fundamental ideas is an approximately 25-metre long freight wagon that can load four 20-foot containers instead of three, which is the usual number today.

In addition to the technical and theoretical analysis a wagon has been built by Tatravagónka which almost meets the specification. It was launched at Innotrans in Berlin 2012 and also won the "Green Corridor Award" prize in Malmö in December 2012.

VEL-wagon: State of the art and concept drafting. Deliverable 1.1. A. Carrillo Zanuy (TUB); H. Boysen (KTH); J. Mašek, M. Buda (UNIZA), F. Janíček, J. Karabin (TVP). TU Berlin 2011-06-10.

VEL-wagon: Intermodal application of VEL-Wagon. Deliverable 2.1. A. Carrillo Zanuy, M. Kendra, J. Čmaj, J. Mašek, S. Stolz, P. Márton. TU-Berlin 2011-11-30.

VEL-wagon: Multipurpose application of VEL Wagon. Deliverable 2.2. Hans Boysen, Peter Márton, Jaroslav Mašek, Juraj Čmaj, Martin Búda, Juraj Jagelčák, KTH 2012-09-17.

VEL-wagon: Study on railway business for VEL-wagon and target costs. Deliverable 3.1. Armando Carrillo Zanuy, Bo-Lennart Nelldal, Hans Boysen. TU-Berlin 2012-04-30.

VEL-wagon: Specification of the basic parameters. Deliverable 4.1. Jan Valigursky, Frantisek Antolik, Juraj Gerlici. Tatravagónka Poprad 2011-11-01.

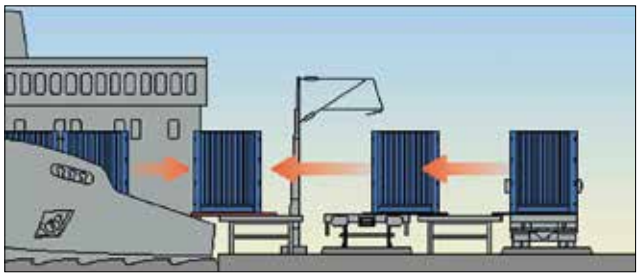
VEL-wagon: Effect on the tracks Deliverable 4.5. Dipl.-Ing. Gonzalo de Ana Rodríguez, Martin Balser TU-Berlin 2012-10-31.

VEL-wagon: VEL-Wagon Concept with basic dimensions. Deliverable 5.1. Dr.-Ing. A. Carrillo Zanuy, Prof. Bo-Lennart Nelldal. Et al. TU Berlin 2012-12-31.

VEL-wagon: Implementation and migration strategy Deliverable 5.2. Bo-Lennart Nelldal, Hans Boysen, (KTH), Anna Dolinayová, Martin Búda, Jaroslav Mašek, (University of Žilina), Erik Batista, Marian Moravčík (Tatravagonka Poprad) KTH 2012-12-31.

ToL 8. TRANSFORUM – Possibilities to realise the goals in the EU's White Paper

Researchers: Jonas Åkerman (MISTRA KTH)
Bo-Lennart Nelldal



Source of funding: EU. Duration: 2013-2014

TRANSFORUM is an EU project that focuses on how to realise four of the ten goals in the White Paper. The aim is to outline roadmaps for achieving these goals and formulate policy recommendations to be submitted to the European Commission and other key actors. A series of workshops will be organised to pinpoint significant recommendations.

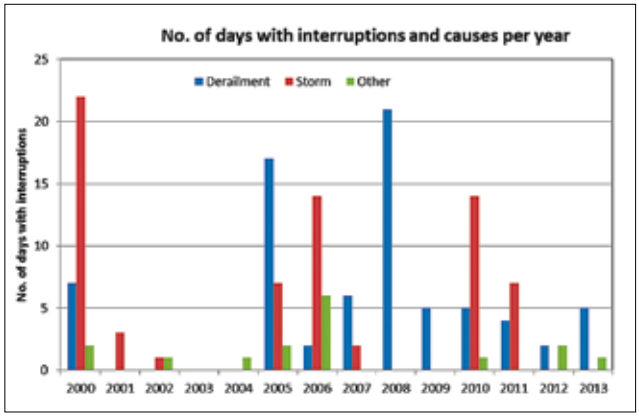
KTH is MISTRA project leader for freight transport and the Railway Traffic Planning Group is also participating. The group will look at challenges, barriers and key trends in relation to Goal 3 of the White Paper:

"30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed."

It is the prerequisites to reach these goals which will be examined by the freight group.

ToL 9. Major traffic interruptions on Sweden's railways 2000-2013 and their impact for customers

Researcher: Bo-Lennart Nelldal



Source of funding: Swedish National Transport Administration (Trafikverket) via WSP. Duration: 2013

In WSP's pilot study on freight time value, methods of calculating the consequences of delays have been discussed and developed. In recent years, major disruptions and interruptions in the railway system lasting one or more days have been increasingly common due among other things to extreme weather conditions resulting from the climate crisis. No overall statistics have been found on major traffic interruptions. KTH has therefore made a survey of these interruptions between 2000 and 2013.

In this report we have made an analysis of major traffic interruptions in the railway's freight traffic between 2000 and 2013. An average of 2.5 interruptions a year thus lasted 5 days and affected approximately 50 freight trains. 2/3 of the operations were handled with diversions. Information provided by the company also confirms the picture given by the survey of major traffic interruptions in Sweden. These appear to have increased in particular after 2005, mainly for two reasons: derailments and extreme weather conditions. Derailments have increased as a consequence of increased traffic and thereby increased wear and backlogged maintenance. The extreme weather conditions have increased due to the climate crisis.

Major traffic interruptions on Sweden's railways 2000-2013 and their impact for transportation customers. Bo-Lennart Nelldal, report KTH 2013-07-01.

Större trafikavbrott vid Sveriges järnvägar 2000-2013 och dess effekter på transportkunderna. Bo-Lennart Nelldal, rapport KTH 2013-07-01.

ToL 10. Efficient freight traffic – high and narrow loading gauge

Researchers: Hans Boysen
Bo-Lennart Nelldal

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2013-2014

The project is part of a project concerning Stage 2 measures for freight transportation. This involves using existing infrastructure more efficiently without any major investments. A high, rectangular loading gauge is of crucial importance for intermodal transportation on the railway. 2.6 metres is sufficient and this is generally not a problem.

When a trailer is loaded onto a railway wagon, height is often a limiting factor. A height of 4.83 m is required, which is called loading gauge P/C 450 because the trailer is 4.5 metres tall.

The problem is that only a limited part of Sweden's railway network has so far been approved for regular traffic with the P/C 450 loading gauge. A review by Railway Group KTH on the other hand showed that a relatively large part of the railway network can permit loading gauge P/C 450 and an even greater proportion if certain obstacles can be eliminated. These obstacles are in most cases minor and can therefore be considered Stage 2 measures. The aim of the project is to report on how a strategic network between intermodal terminals and ports for P/C 450 might look and be extended in stages and make an overall estimate of the costs involved.

Higher loading gauges for intermodal transportation and wagonloads can increase market coverage and efficiency. Hans Boysen. XXXIV International Conference on Railway Engineering and Management, Copenhagen 2013.

Developing larger loading gauges for Europe. Hans Boysen, 10th World Congress on Railway Research, Sydney 2013.

ToL 11. Future freight transportation in the Eastern Sweden Region 2010-2030-2050

Researchers: Bo-Lennart Nelldal
Jakob Wajsman (Trafikverket)

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2011-2013

In 2009 Railway Group KTH published its study on forecasts of demand and capacity at Stockholm Central Station in 2050 ("Stockholm Central 2050 – prognoser över efterfrågan och kapacitetsbehov"). KTH has also made a forecast for passenger and freight traffic between 2010 and 2030 with a capacity analysis for the whole country. Both of these point to a greater need for passenger and freight transportation in the Stockholm region and eastern central Sweden.

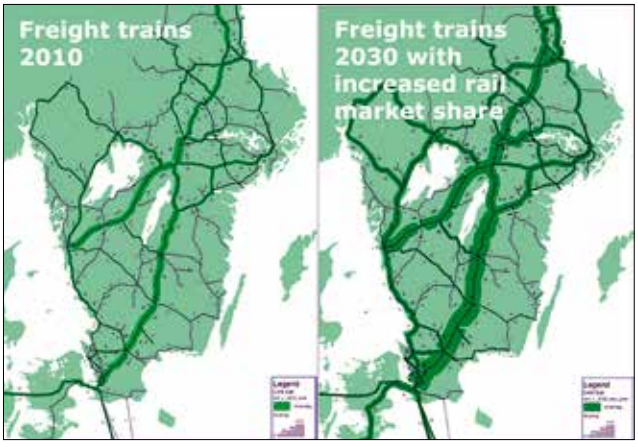
Against this background Railway Group KTH has been commissioned to make an analysis, in collaboration with the Swedish Transport Administration, of the market for freight transportation by rail in eastern central Sweden based on the total demand in the region. Forecasts are shown for 2030 and 2050 both for the whole country and various parts of eastern central Sweden. Against this background a vision is presented of a developed transport system in 2050 based on the railway. The aim is to as far as possible attain the objectives stated in the EU's White Book on a long-term sustainable society and point out strategic issues regarding freight transportation. The results were published in a report in 2013.

Person- och godstransporter 2010-2030 och kapacitetsanalys för järnväg. Jakob Wajsman, Trafikverket och Bo-Lennart Nelldal, KTH Rapport TRITA-TSC-RR 12-003, Stockholm 2012.

Godstransporter i Östra mellansverige 2010-2030-2050 - En vision med prognoser för ett utvecklat transportsystem med järnväg. Jakob Wajsman (Trafikverket) och Bo-Lennart Nelldal (KTH). KTH rapport TRITA-TEC-RR 13-007 Stockholm 2013.

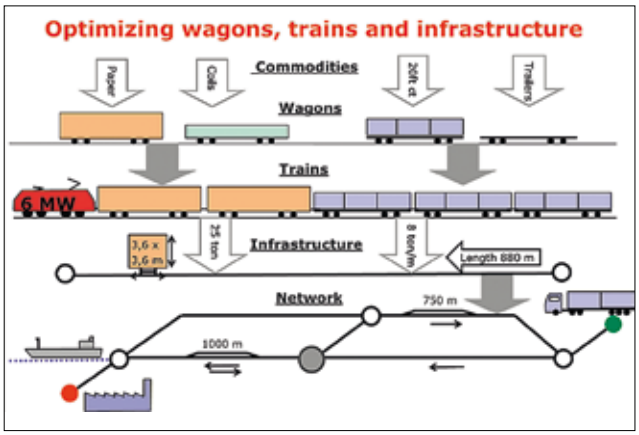
Another paper about future transports:

Mode shift as a measure to reduce greenhouse gas emissions. Bo-Lennart Nelldal, Evert Andersson. Paper 635 at Transport Research Arena in Athens 2012.



ToL 12. - Green Freight Train - Roadmap for rail and intermodal freight transportation

Researchers: Bo-Lennart Nelldal
Oskar Fröidh



Source of funding: VINNOVA. Duration: 2012-2013

The purpose of HCT for the railways/Gröna Godståget (Green Freight Train) is to draw up a programme to develop more efficient transport systems where the railway constitutes a high-capacity transport mode of high quality. It contributes to improving trade and industry's transportation possibilities and to customers choosing the railway and intermodal transport to a greater extent. Since the railway has low energy consumption and emissions per transported unit and these can also be reduced further, this contributes to a reduction in energy consumption and emissions both from the railway itself and from the transport system as a whole. Greater capacity also often leads to lower cost per transported unit.

During 2012 and 2013 KTH devised a programme for KTH's research and demonstration projects for future freight transportation by rail. KTH has also been commissioned by the Forum for Innovation in the Transport Sector to draw up a road map for High Capacity Transport (HCT) on the railways. In 2013 and 2014 KTH will continue with this and apply for funds to implement research, development and demonstration projects.

Roadmap for development of rail and intermodal freight transportations - High Capacity Transport for rail - Green Freight Train. B-L Nelldal, KTH Railway Group Report 2013, KTH TRITA-TSC-RR 13-006.

Färdplan för utveckling av godstransporter på järnväg och kombitransporter- High Capacity Transports för järnväg – Gröna godståget. B-L Nelldal, KTH Järnvägsgrupp rapport 2013, KTH TRITA-TSC-RR 13-005.

Effektiva gröna godståg- Åtgärder för ökad kvalitet, kapacitet och minskad kostnad. B-L Nelldal, KTH Järnvägsgrupp rapport 2013, KTH TRITA-TSC-RR 13-004.

PASSENGER TRANSPORT AND CUSTOMER PREFERENCES

ToL 13. Gröna tåget with active lateral suspension – evaluation of comfort

Researchers: Oskar Fröidh
Jennifer Warg
Hans Sipilä

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2005–2013

The aim of the Gröna tåget (Green train) research programme 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 program of railway research and standardisation.

In this project, Railsys is used to calculate running times for trains with different performance on a number of typical lines of varying standard. It concerns a number of different variables such as top speed, with and without overspeed and carbody tilting at different inclinations, with different cant deficiency and track geometry and output in KW/ton (acceleration).

Within this project, an evaluation was made in 2013 of customers' valuation of active lateral suspension (ALS). Active lateral suspension increases comfort so that a non-

tilting train can run faster in curves. Trials have been carried out operating a non-tilting Regina train, but equipped with ALS, on the X2000 schedule (made for tilting trains) between Stockholm and Hallsberg.

Fröidh, Oskar (2010) Resande och trafik med Gröna tåget, KTH Järnvägsgruppen publikation 1001.

Kapacitetsanalys av Södra stambanan" inom ramen för Gröna Tåget. KTH Järnvägsgruppen publikation 1203 ISBN 978-91-7501-288-9. Hans Sipilä och Jennifer Warg 2012.

Green train. Basis for a Scandinavian high-speed train concept. Oskar Fröidh. Final report, part A KTH Railway Group, publication 12-01. Stockholm 2012.

Another report about future passenger train systems:

Tågtrafiken Stockholm-Östersund-Trondheim med en elektrifierad Meråkersbana - Scandinavian Express Loop i ett långsiktigt perspektiv. Bo-Lennart Nelldal. Rapport TRITA-TEC-RR 13-008, Stockholm 2013.

ToL 14. High-Speed Trains in Sweden – Supply and demand

Researchers: Bo-Lennart Nelldal
Oskar Fröidh
Jennifer Warg

Source of funding: Various. Duration: Continuous.

High-speed trains have existed in Japan since 1964 and in France since 1981. Sweden has had a vision of the Götaland Line and the Europa Line. This involves the construction of a completely new railway line from Stockholm (Södertälje) to Norrköping-Linköping via Nyköping-Skavsta (the East Link) and from there to Jönköping and on to Borås and Göteborg (The Götaland Line). From Jönköping a southward branch is planned to Helsingborg/Malmö and on to Helsingör-Copenhagen and via the fixed link at the Fehmarn Belt to Hamburg.

The fundamental characteristic of high-speed trains is that they travel fast, between 300 and 350 km/h, and thus give extremely short journey times. When the fast trains are removed from the conventional lines, capacity is freed up for freight trains and regional trains on the main lines and the fast trains can travel on the high-speed lines with both high capacity and high punctuality.

KTH Railway Group has participated in several studies and research projects concerning high-speed trains. During 2009 KTH Railway Group participated in the commission on high-speed trains appointed by the Government. In 2012 the government also finally proposed the construction of the first parts of the Swedish High Speed Network.

The following reports have been published by KTH in the recent years:

Höghastighetsbanor i Sverige, Trafikprognoser och samhällsekonomiska kalkyler med Samvips-metoden för utbyggda stambanor och separata höghastighetsbanor. Rapport TRITA-TEC-RR 10-005. Bo-Lennart Nelldal, Kjell Jansson, Chris Halldin 2010. Includes summary in English: High-speed lines in Sweden Traffic forecasts and socioeconomic calculations using the Samvips method for expanded main lines and separate high-speed lines.

High-speed trains in Sweden – a good idea? by Kjell Jansson and Bo-Lennart Nelldal, Royal Institute of Technology (KTH), Stockholm, Sweden. Paper at WCTR 12th congress in Lisbon, 11-15th July 2010

Europakorridoren: Kapacitet och restider. Oskar Fröidh och Jennifer Warg. Rapport TRITA-TSC-RR 13-009.

ToL 15. HSLdim - Optimal speed for new high-speed railways

Researchers: Oskar Fröidh
Jennifer Warg

Source of funding: TRENOP. Duration: 2011–2013

Planning of new high-speed lines has often lacked an analysis of the system parameter dimensional speed from a market perspective and a socio-economic perspective.

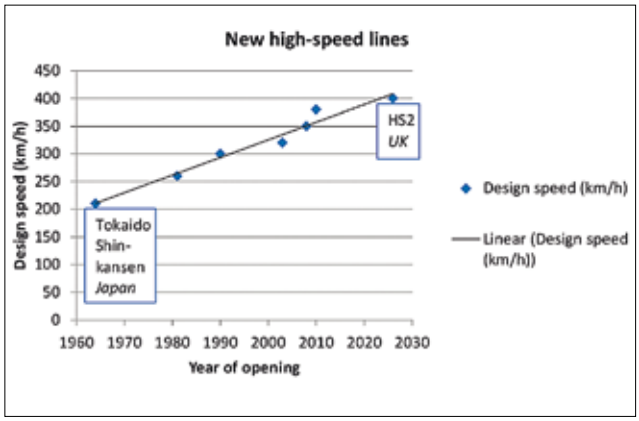
Top speed is of crucial importance for travelling times and consequently benefits and costs, but a new line with a high dimensional speed is on the other hand as a rule more expensive to build than a line for lower speeds.

The speed parameter has hitherto in practice been based more on performance with current technology than a result of cost-benefit optimisation. This can easily lead to planning and building high-speed lines that either have unexploited

potential and may perhaps be more expensive than necessary or are not futureproof and generate less-than-optimal benefits.

HSLdim (High-Speed Line dimensional speed) is a research project of which the purpose is to devise a model for calculating the optimal dimensional speed for new high-speed lines at the planning stage. The model is based on empirical construction and maintenance costs for new lines and modelled train traffic costs. The benefits of a new line are dependent on the demand for travel by high-speed train. Demand calculations are consequently an important component of the model.

Optimising design speed for new high-speed lines. Oskar Fröidh. Paper for presentation at 10th World Congress on Railway Research (WCRR), Sydney 25th – 27th November 2013.



ToL 16. Development of forecast models – Forecast model based on scenarios

Researchers: Bo-Lennart Nelldal
Josef Andersson
Sten Svalgård (WSP)

Source of funding: Swedish National Transport Administration (Trafikverket) and others. Duration: Continuous.

Together with, among others, ÅF infrateknik, KTH Railway Group has been working for a long time on developing the Samvips forecast model. The background is that the Swedish national forecasting system, Sampers, does not function satisfactorily for forecasts of, principally, interregional public transport, which became particularly apparent in connection with major system changes like the introduction of high-speed trains. A method has been developed where Sampers' matrices are distributed over transport modes, routes and lines using the Vips/Visum forecasting tool.

One problem when making forecasts is to compile detailed data of both a population and its regional distribution and traffic networks and public transport supply. This project is developing a scenario-based forecasting model where data from for example a random survey can be used on an aggregated level.

A regional division developed earlier and which proved to have great explanatory value is locality regions. By using locality regions, forecasts can be made on an aggregated level that is then broken down to a disaggregrated level. Railway Group KTH and WSP have earlier developed a car ownership model based on locality regions which worked well.

Bilinnehavsmodell - Utveckling av bilinnehavsmodell med beroende av tillgänglighet till trafiksystemet. Joakim Köhler (WSP) och Oskar Fröidh (KTH). Transek rapport 2005:25.

Scenariobaserad prognosmodell – förstudie. Bo-Lennart Nelldal, KTH Prel. rapport 2013, Include summary in English: Forecast model based on scenarios

ToL 17. Database of supply and prices for railway-lines in Sweden

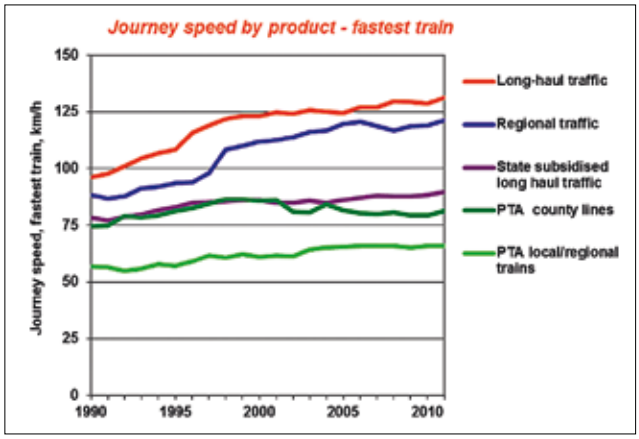
Researchers: Bo-Lennart Nelldal
Josef Andersson
Gerhard Troche

Sources of funding: Banverket (The Swedish Rail Administration), Trafa (Transport Analysis) and Transportstyrelsen (The Swedish Transport Agency) Duration: 1990–2013

On behalf of Banverket the department of Transportation and Logistic has continuously built up a database of supply and prices for 85 railway lines in Sweden. The database now consists of the years 1990-2013 and is planned to be updated every year. The content is facts about travel times, frequency and prices for relations for different products (i.e. high-speed, InterCity, commuter trains) for SJ traffic, regional authorities' traffic, state subsidized traffic and private traffic.

Utveckling av utbud och priser på järnvägslinjer i Sverige 1990-2011 samt Utvärdering av avreglering och konkurrens mellan transportmedlen i långväga trafik. Rapport TRITA-TEC-RR 12-006. Bo-Lennart Nelldal, Oskar Fröidh och Gerhard Troche, 2012.

Development of supply and prices for railway lines in Sweden 1990-2011 and deregulation and competition between modes in long distance traffic – summary in English. KTH 2012.



ToL 18. Evaluation of the deregulation and competition in long distance traffic in Sweden

Researchers: Bo-Lennart Nelldal
Oskar Fröidh

Sources of funding: Trafa and Transportstyrelsen. Duration: 2009–2013

The work of describing the development of supply and prices on Sweden's railway lines also includes describing the effects of deregulation and competition between different transport modes in long-distance traffic. For the first time this report also contains details of long-distance air and bus services that compete with the railway.

Work is currently ongoing to describe development during 2012 and 2013 and applications for competing train traffic for 2014. Commercial traffic competing with SJ's services has hitherto been limited. For 2014, however, several operators have applied for train paths for a large number of express trains between Stockholm and Gothenburg. An account of the project will be given in a coming report on supply and prices from 1990 to 2013.

Interregional tågtrafik i konkurrens på Västkustbanan Oskar Fröidh och Camilla Byström. Rapport TRITA-TSC-RR 12-004, Stockholm 2012.

Another report about improved passenger service:

Resandet längs Blekinge kustbana - före, under och efter elektrifieringen. Oskar Fröidh och Karl Kottenhoff. Rapport TRITA-TEC-RR 09-005, Stockholm 2009.

ToL 19. Future maintenance and depots – research program

Researcher: Oskar Fröidh
Mats Berg

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2013–2014

Over the past 10 years, as a consequence of the expansion and deregulation of train traffic, a number of new depots have been built and more are planned. Knowledge of how maintenance can be carried out and how depots can be designed and situated is limited. Where the depots are located also affects the railway network's capacity.

Consulting firms Ramböll and Transrail have made some preliminary studies in this area.

The Swedish Transport Administration, however, wishes to increase knowledge of depots and maintenance and is seeking to build up research in this area. Railway Group KTH has therefore been commissioned to lead the work of developing a research programme in this area. The work will be done in collaboration with Chalmers and the School of Business, Economics and Law at the University of Gothenburg.

CAPACITY ANALYSIS AND SIMULATION

ToL 20. Congested infrastructure

Researcher: Anders Lindfeldt

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2009-2014.

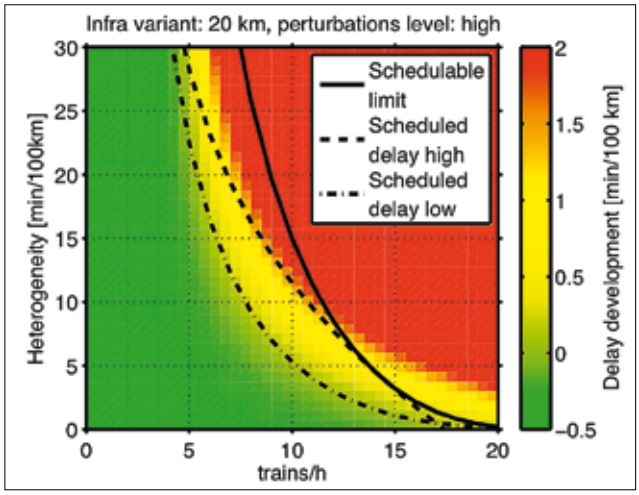
The load on the Swedish rail network is increasing and parts of the rail network have been declared to be overloaded. The purpose of the project is to analyse what the capacity limit for rail traffic is under different prerequisites. One approach is to analyse how the load on the rail network affects the risk of delay. Another approach is to try to find a "volume-delay" function for train traffic, i.e. the limit where the infrastructure becomes so loaded that delays increase, causing capacity to fall. This makes it possible to determine the limit for a robust timetable with different prerequisites.

First, a database of the Swedish rail network was created, with data on the infrastructure, the number of trains, the timetables and the delays. An analytical model of a double track railway line has been built. The model is used to

analyse how departure delays are affected by different arrival delays and choice of timetable structures, etc. A large number of simulations are then made in a simulation tool. The simulation results are validated against actual research statistics and compared with the results from the analytical model.

The results will for example be able to be used to calculate how many train paths can be permitted without punctuality falling below a set limit, given a certain type of arrival delay. A licentiate thesis was published 2012 and a doctoral project is ongoing.

Congested railways-Influence of infrastructure and timetable properties on delay propagation. Licentiate Thesis TRITA-TSC-LIC 12-005. Anders Lindfeldt 2012.



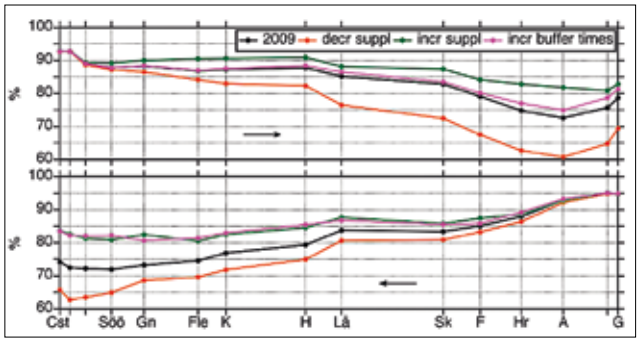
ToL 21. Timetable planning with simulation

Researcher: Hans Sipilä

Sources of funding: Swedish National Transport Administration (Trafikverket) and SJ. Duration: 2009-2014.

As railway traffic increases, the infrastructure is being used more and more intensively and after deregulation more and more operators want to use the tracks, which increases complexity at the same time as demands for flexibility in the timetables are growing. This project aims to analyse if it is possible to improve timetable planning by drawing up timetables with the help of simulation. The purpose is to study whether it is possible in the long term to speed up the planning process and raise the quality of the timetables by being able to simulate the effects of different proposed timetables in advance.

A further purpose of this project is to try to find timetable designs that give better punctuality for the X2000 traffic. Both adjustments of time additions and margins between the trains in today's timetable and major structural changes in the traffic designs that can be made in the long term are being studied. The intention is also to try to create simple,



usable guidelines for timetable planning.

The project started with the Western Main Line Stockholm-Göteborg and continued with the Southern Main Line Stockholm-Malmö. Next step is the single track on the East Coast Line Gävle-Sundsvall. A licentiat thesis was published 2012 and a doctoral project is going on.

Simulation of rail traffic - Applications with timetable construction and delay modelling. Licentiate Thesis TRITA-TSC-LIC 12-003. Hans Sipilä 2012.

ToL 22. Development of time table strategies

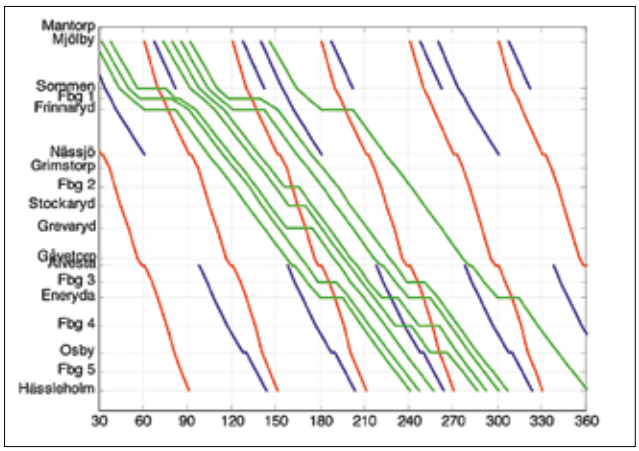
Researcher: Jennifer Warg

Sources of funding: KTH Railway Group.

Duration: 2012-2016.

Railway Group KTH at the Division of Traffic and Logistics has done extensive work on analysing the effects in the form of delays in various operating strategies and measures in the infrastructure. Results are normally measured in terms of punctuality and delays.

The intention of this project is to evaluate the results of simulations in the form of benefits and costs for travellers, transportation customers and railway companies of



implementing various measures. This would make it possible to calculate the socioeconomic benefit and choose between different measures. The primary aim is to develop a method to evaluate timetable measures and then infrastructure measures where investment costs also come into the picture.

As regards benefits, there is a connection with research on evaluations made at KTH regarding for example the value of travelling time, frequency of service and delays. The linkages between business-economic costs through the cost models that have for example been developed in the Gröna tåget and freight transportation models are also part of this.

A connection with the forecasting models developed with the Samvips method is also possible.

This is a doctoral student project where a licentiate thesis is planned for 2014 and a doctoral thesis for 2016.

Effects of increased traffic and speed on capacity of a highly-utilized railway. Jennifer Warg, 13th International Conference on Design and Operation in Railway Engineering (Comprail), New Forest, 2012.

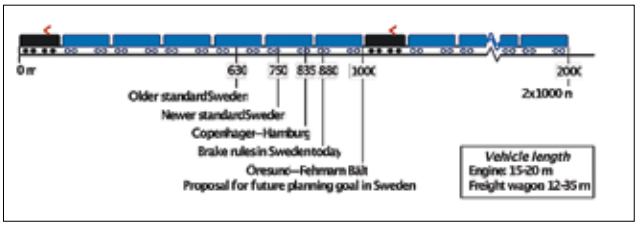
Economic Evaluation of time table strategies with simulation. Jennifer Warg, 10th World Congress on Railway Research (WCRR) Sydney 2013.

ToL 23.Freight traffic by rail – measurments for increased capacity

Researcher: Oskar Fröidh

Source of funding: SOU Fossilfri Fordonsflotta (FFI). Duration: 2012-2013.

This is a background report to the Swedish Government Official Report "Fossilfri fordonsflotta" (approximately Vehicles independent of oil). The results show that considerably more freight can be transported by rail than is carried today and what the Swedish Transport Administration has calculated in its base forecasts for 2030 and 2050. However, freight traffic will have less space on the tracks as passenger traffic expands. Various measures can be considered to handle freight traffic. Standard factors like higher axle loads and greater bearing capacity (load/metre) a larger loading gauge and longer and heavier freight trains are essential to increase efficiency and reduce energy



consumption and transport costs. To cope with freight traffic over and above the base forecast (+50 % and +100 %, respectively), extra investment is needed, mainly in extended crossing and passing tracks and marshalling yards for train lengths of 1,000 and 2,000 metres and some double-track sections.

Godstrafik på järnväg - åtgärder för ökad kapacitet på lång sikt. Fröidh, Oskar (2013). KTH rapport TRITA-TSC-RR 13-003.

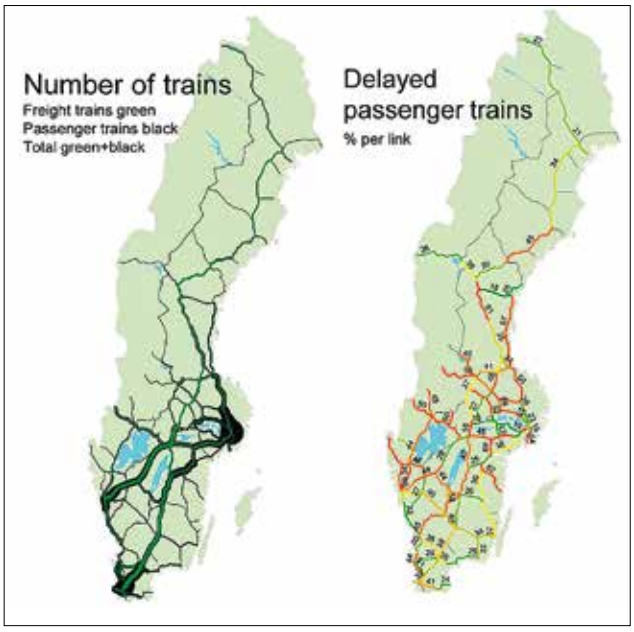
ToL 24 Analysis of capacity and punctality 2008-2012

Researcher: Anders Lindfeldt

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2013.

In 2009 KTH was commissioned by the Swedish Transport Administration to conduct a major project called "Capacity analysis of the rail network in Sweden". A sub-project developed a database of timetable data, delay data, BIS and traffic statistics for 2008. A large number of measures of capacity utilisation were devised and calculated for all links in the Swedish railway network. Examples include speed mixing, delays per 100 km, mean train size and mean train length of freight trains. These were also shown on maps with colour codes to indicate the loadings on the different links.

A lot has happened on the railway since 2008. Traffic has increased but delays have also caused serious problems during certain periods. In 2013, KTH therefore received a grant from the Swedish Transport Administration to



update this database and analyse the changes that had taken place between 2008 and 2012. The purpose is to refine the analyses. The analyses are also intended to constitute one of the bases for the National Audit Office's study of the capacity planning process.

Bearbetning och analys av databas över infrastruktur, trafik, tidtabell och förseningar. Anders Lindfeldt. Rapport TRITA-TEC RR 10-03, Stockholm 2010 with summary in English: Processing and analysis of a database of infrastructure, traffic, timetables and delays.

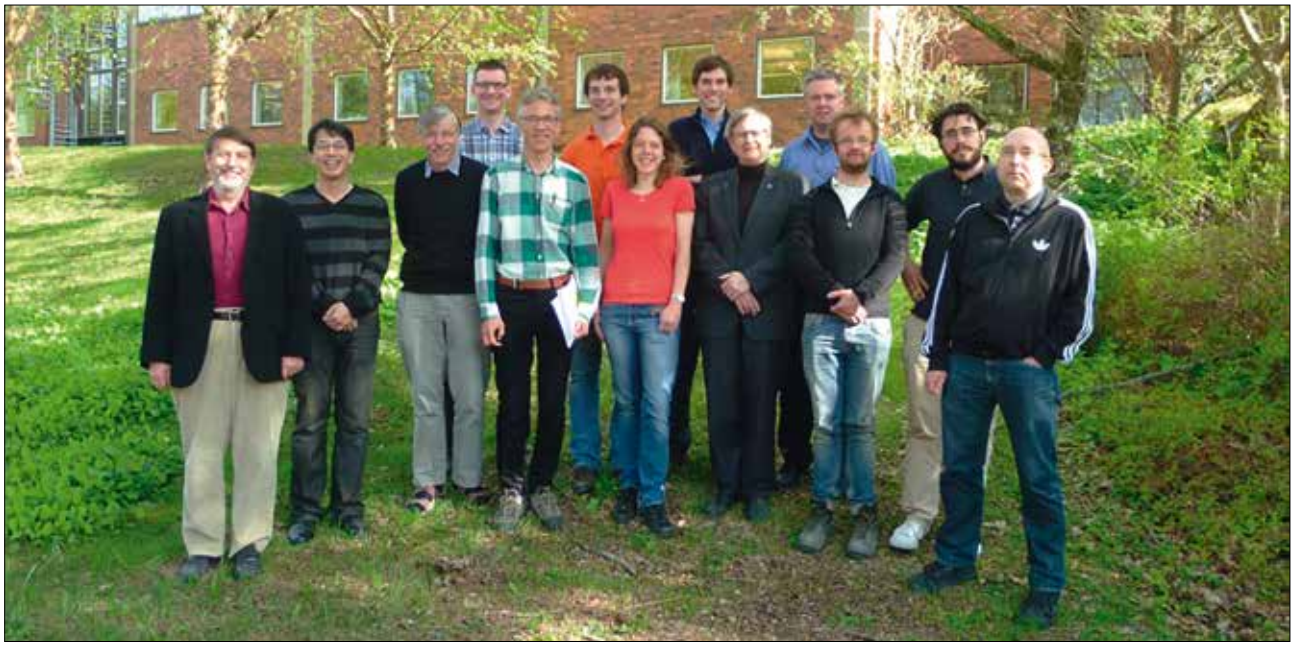
ToL 25. Analysis of time-tables, delays and capacity utilization by KAJT

Researchers: Anders Lindfeldt
Hans Siplila
Jennifer Warg

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2013-2014.

KAJT – Kapacitet i JärnvägsTrafiken – is an industry-specific programme for interaction between the academic world, authorities and the railway industry. The academic partners are Linköping University (LiU), Kungliga Tekniska Högskolan (KTH, Royal Institute of Technology), Blekinge Tekniska Högskola (BTH, Blekinge Institute of Technology), Statens väg- och trafikforskningsinstitut (VTI, The Swedish National Road and Transport Research Institute), SICS Swedish ICT och Uppsala University (UU). KAJT funds research in the capacity field, primarily through the Swedish Transport Administration.

Railway Group KTH currently has two collaborative projects within KAJT. One is a pilot study of measures, effects, market and strategic decisions on infrastructure and traffic operation together with VTI and SICS. The aim is to create a common methodology for processing and analysing delay statistics and capacity utilisation. The other project is a pilot study on follow-ups, capacity planning, simulation and traffic control in collaboration with BTH, SICS and UU. The aim is to follow up a train plan with the help of models for optimisation, simulation and decision support.



The Capacity Group at Transport and Logistics had a seminar at KTH in Stockholm with researchers from RailTEC University of Illinois at Urbana Champaign, US, in May 2013.

ToL 26. Analysis of track access charges and the rail market

Researchers: Bo-Lennart Nelldal
Jakob Wajsman (Trafikverket)

Source of funding: Swedish National Transport Administration (Trafikverket). Duration: 2013-2014.

Together with the Swedish Transport Administration, Railway Group KTH has evaluated different alternatives for changes in track access charges in Sweden. Databases and models have been built up for this purpose and have been used in several studies.

The project will describe the development of track access charges over the past 10 years alongside the development of the railway's market over the same period. The development of capacity utilisation and punctuality will also be described. Finally, a number of different scenarios for track access charges will be developed and possible consequences for capacity utilisation will be described

ToL 27. Program for research and innovation in signalling systems

Researchers: Gustaf Lindström
Anders Lindahl

Source of funding: VINNOVA. Duration: 2012-2013.

Sweden has been among the leaders as regards signalling systems for track-bound traffic. One example of this is the international ERTMS system for railway traffic where Sweden has played a prominent role. A continued focus on research, education and innovation in collaboration between the academic world, suppliers, users and creative developers is needed If we are to strengthen and maintain our position.

The aim of this project is to draw up an agenda for research and innovation for future cooperation within a future innovation platform. The project is being run as a series of workshops with KTH acting as process leader. A number of different organisations have participated in the project including, in addition to KTH: SICS, VTI, Bombardier and the Swedish Transport Administration. A proposed agenda has been drawn up as a basis for future research. A project proposal with simultaneous simulation in different environments of capacity, driver's environment and operational traffic control has been drawn up.

Strategisk F&I-agenda - Signalsystem för Spårtrafik. Jan Ekman, SICS, Peter Feltenmark, Bombardier, Magnus Karström, Trafikverket, Anders Lindahl, KTH och Gustaf Lindström, KTH Järnvägsgruppen, rapport 2013-03-31.

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