Publication 0701

The KTH Railway Group

Annual Report 2005–2006

Contents

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Cover photo: Gröna Tåget (The Green Train). Photo: Bombardier Transportation

The KTH Railway Group 2005–2006

The project portfolio of the KTH Railway Group has during the last two years undergone important changes. Several new projects in new areas have been initiated. The two largest ones are the Green Train project and TIMM (Train Information Monitoring and Management). The ultimate objective of the Green Train project is to develop a specification for new high-speed trains for Swedish and Nordic conditions. Several of the sub-projects are follow-ups on previous successful projects like the ones on *Efficient train systems for passenger services* and *Active lateral suspension,* but there are also completely new areas like *Permanent magnet traction motors*.

The TIMM project is focused on features like Condition monitoring and Diagnosis of trains and train operation. It is in co-operation with the Swedish Institute of Computer Science, SICS. The combination of our Rail expertise and their expertise in Computer Science and applied mathematics is really applicable to many railway issues.

As a consequence of these new projects our partners have somewhat reduced their contributions to the new frame work program for 2007–2009. However, including the contributions to the Green Train and the TIMM project the result is an increase in the total research fundings.

In late 2006 the first call for the EU FP7 was issued. The KTH Railway Group has been active in the EURNEX network of excellence and has got a positive feed-back from European colleagues and not at least useful support from the partners Banverket and Bombardier Transportation. We are now active in several proposals and hopefully we will be able to get some contracts.

The number of doctoral degrees is rather constant compared with the previous period 2003-2004 whereas the number of licentiate degrees has decreased. The decrease is partly a consequence of the fact that we did not recruit that many Ph.D. students in 2001-2002 due to the dip in funding at that time.

It is more severe that the number of students taking our courses still is low and even lower than a few years ago. KTH is today a very international university. It is obvious by the fact that at least 50% of the students in the fourth and fifth year are either studying in our international master programmes or are exchange students mainly from other European universities. Only one of our courses is adapted to English (Rail Vehicle Dynamics) and to be able to increase the interest for railway courses we have to translate text books and course material and do all instruction in English. It is a costly issue but necessary. If so, we will also be able to provide courses to the proposed virtual European university for Railways, EURail.

A more positive change is the considerable increase in the number of papers submitted to journals and conferences.

Stefan Östlund
Director of the KTH Railway Group

1. The Board 2005–2006

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

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2. Research Groups

The Railway Group KTH consists of eight research groups, each representing different parts of the railway system. Below is a brief presentation of each group and its contribution to railway research and education.

2.1 Rail Vehicles

The activities at the Division of Rail Vehicles mainly focus on rail vehicles and their dynamic interaction with the track. Research is also carried out on topics like sound and vibration from a railway passenger perspective, and on energy consumption and running times. In addition, the division is responsible for two undergraduate courses and external courses.

Personnel

Professor	Mats Berg, Ph.D.	mabe@kth.se
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	Dirk Thomas, Dipl-Ing	dthomas@kth.se

M.Sc. courses

Railway Systems and Rail Vehicles: 6 credits / 9 ECTS credits (4B1304, 4B4304).
Rail Vehicle Dynamics: 5 credits / 7.5 ECTS credits (4B1313, 4B4313); the course is given in English.

RESEARCH PROJECTS

1. Running gear for freight wagons (SAMBA 1)

Researchers: Sebastian Stichel, Evert Andersson, Per-Anders Jönsson
Sources of funding: Banverket, Bombardier Transportation, SL AB, Tågoperatörerna, Interfleet Technology.
The European standardised designs of freight wagons and their running gear are 40–50 years old. To increase competitiveness of freight transport on rail it is desired to increase axle load and/or speeds, but this would - at least for some operating conditions for standard running gear - mean to exceed existing limit values for ride quality and wheel-rail forces. At least as important is to improve ride qualities in order to reduce damages on transported goods and being able to attract customers that require transport service for sensitive and high-value goods.

The project is firstly aimed to study and learn how freight wagons behave dynamically on track. This is made both for standardised running gear and for novel designs. The second step is to analyse and test possible improvements in the designs, in particular the standardised designs now dominating in Europe. In the project special attention is given to the very common link suspensions, their characteristics and the possible effects on variations in the characteristics. Substantial improvements by means of additional hydraulic dampers have been suggested and tested on modified two- and four-axled wagons on track. Speeds up to 170 km/h have been tested.

A third part of this project is to investigate the causes of track deterioration and to propose mathematical models for prediction of deterioration.

The project will continue at least until the summer 2007, when the Ph.D. thesis by Per-Anders Jönsson is foreseen.

Jönsson P-A och Andersson E, *Godsvagnar, dynamik, komfort och spårkrafter – Test och simuleringar*, 13:e Nordiska seminariet i järnvägsteknik, Hamar, Norge, 10-11 maj 2005.

Andersson E and Jönsson P-A, *Development of freight wagons*, European Railway Review, Issue 2, 2005.

Jönsson P-A, Stichel S and Andersson E, *Influence of link suspension characteristics variation on two-axle freight wagon dynamics*, Proceedings of the 19th IAVSD Symposium, pp 415-423, Milan, Italy, 29 Aug – 2 Sep, 2005.

True H, Hoffmann M and Jönsson P-A, *The design and performance of the European freight wagon standard suspensions*. Proceedings of the 2005 ASME International Mechanical Engineering Congress and Exposition, November 5-11, 2005, Orlando, Florida, USA.

Jönsson P-A, Stichel S, Andersson E, *Experimental and theoretical analysis of freight wagon link suspension*. Proc. IMechE Vol 220 Part F: J. Rail and Rapid Transit, pp. 361-372, 2006.

Jönsson P-A and Stichel S, *Godsvagnar, hjulpar och styrförmåga*, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

Öberg J, *Track deterioration of ballasted tracks*, M.Sc. Thesis, TRITA AVE 2006:88, KTH Rail Vehicles, 2006.

2. Wear on wheels and rails (SAMBA 2)

Researchers: Mats Berg, Roger Enblom
Sources of funding: Banverket, Bombardier Transportation, SL AB, Tågoperatörerna, Interfleet Technology
The overall aim of the project is to improve the knowledge on how wheels and rails wear over time as functions of vehicle design, track geometry and operational conditions. With relevant wear models and vehicle dynamics procedures, different actions on wear and cost reductions can be suggested already from computer simulations. For instance, choice of initial wheel and rail profiles along with different turning and grinding strategies can be proposed. Vehicle based vs. track based lubrication is another practical topic that the project can support. Thus simulations of successive wheel and rail wear, and how the vehicle-track interaction is changed, have large potential on efficient optimization of different railway systems.

The project was essentially finished in 2006 with the Ph.D. thesis of Roger Enblom.

Enblom R and Berg M, *Simulation of railway wheel profile development due to wear – Influence of disc braking and contact environment*, WEAR, Vol 258, pp. 1055-1063, 2005.

Orvnäs A, *Simulation of rail wear on the Swedish light rail line Tvärbanan*, M.Sc. Thesis, Report TRITA AVE 2005:12, KTH Railway Technology, 2005.

Enblom R, *Ingenjörsmetoder för simulering av nötning*, 13:e Nordiska seminariet i järnvägsteknik, Hamar, Norge, 10-11 maj 2005.

Enblom R, *Emerging wheel/rail wear simulation procedures*, EURNEX Mini-symposium on Dynamic train-track interaction with applications, Chalmers, Göteborg, 19 May 2005.

Enblom R and Berg M, *Emerging engineering models for wheel/rail wear simulation*, Conference of Railway Engineering 2005, London, June 29-30, 2005. Proceedings: CD 2005.

Nilsson R and Berg M, *Wheel profile wear development – Measurements on Stockholm commuter trains X1 and X10*, Report TRITA AVE 2005:46, KTH Railway Technology, 2005.

Enblom R and Berg M, *Impact of non-elliptic contact modelling in wheel wear simulation*, Proceedings of the 7th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, pp. 619-628, Brisbane, 24-27 September, 2006.

Bevan A, Allen P and Enblom R, *Application of a wear prediction method to the analysis of a new UK wheel profile*, Proceedings of the 7th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, Brisbane, 24-27 September, 2006.

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

Brodén E, *Wheel wear and reduced reprofiling for Swedish Rc4 loco*, M.Sc. Thesis, TRITA AVE 2006:106, KTH Rail Vehicles, 2006.

3. Modelling of rail vehicle dynamics (SAMBA 3)

Researchers: Mats Berg, Nizar Chaar
Sources of funding: Banverket, Bombardier Transportation, SL AB, Tågoperatörerna, Interfleet Technology
The overall aim of the project is to improve the knowledge and mathematical models of the dynamics of the vehicle-track system and its components. In this way the potential of vehicle-track interaction simulations can be raised and become a very important and reliable tool in the design of new vehicles or in modifications of existing vehicles. The vehicle impact on track and track damage can also be better understood and appropriate actions can be suggested.

The project continues until the spring of 2007 when the Ph.D. thesis by Nizar Chaar is foreseen.

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

Chaar N and Berg M, *Vehicle-track dynamic interaction – Simulations with flexible wheelsets, moving track models and measurements*, 13:e Nordiska seminariet i järnvägsteknik, Hamar, Norge, 10-11 maj 2005.

Chaar N and Berg M, *Simulation of vehicle-track interaction with flexible wheelsets, moving track models and field tests*, Proceedings of 19th IAVSD Symposium, pp. 921-931, Milan, Italy, 29 Aug - 2 Sep, 2005.

Claesson S, *Modelling of track flexibility for rail vehicle dynamics simulation*, M.Sc. Thesis, Report TRITA AVE 2005:26, KTH Railway Technology, 2005

Parczewski E, *Modelling and simulation of train coupling dynamics*, M.Sc. Thesis, Report TRITA AVE 2005:47, KTH Railway Technology, 2005.

Chaar N, *Simulation of vehicle-track interaction with flexible wheelsets, moving track models and field tests*, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

4. Track stiffness, irregularities and maintenance (SAMBA 7)

Researchers: Mats Berg, Eric Berggren (Banverket)
Source of funding: Swedish National Rail Administration (Banverket)
The track stiffness, in particular vertically, is more and more often related to track standard and track maintenance. The first purpose of this project was to develop a methodology and a new wagon for continuous measurements of track stiffness as the wagon travels along the track. A two-axled freight wagon was rebuilt for this purpose in close collaboration with Banverket. Various tests have been carried out on different Swedish railway lines with encouraging results. In particular, interesting findings have been achieved for tracks at rather poor soils like clay and peat. A licentiate thesis was completed in 2005. Now the project is also including track irregularities for a combined analysis and evaluation of fundamental track problems and possible maintenance solutions. System identification methods will be used in this context. The work is also related to the EU project INNOTRACK. The project is planned to run until June 2009.

Berggren E, *Dynamic track stiffness measurement - A new tool for condition monitoring of track substructure*, Licentiate Thesis, Report TRITA AVE 2005:14, KTH Railway Technology, 2005.

Berggren E, Jahlénius Å, Bengtsson B-E and Berg M, *Simulation, development and field testing of a track stiffness measurement vehicle*, 8th Int. Heavy Haul Conference, Rio de Janeiro, 13-16 June, 2005.

Berggren E, *The role of vertical track stiffness measurements in condition based maintenance of railway tracks - A pilot study*, Report TRITA AVE 2005:31, KTH Railway Technology, 2005.

Berg M, *Spårlägets nedbrytning och toleranser*, Transportforum, Linköping, 12-13 januari 2005.

Berggren E, Smekal A 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.

Berggren E, Li M and Spännar J, *A new approach to the analysis and presentation of vertical track geometry quality and rail roughness with focus on train-track interaction and wavelength content*, Proceedings of 7th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2006), Brisbane, 24-27 September, 2006.

5. Influence of low-frequency vibrations on passenger activities (SAMBA 8)

Researchers: Shafiquzzaman Khan, Evert Andersson, Johan Förstberg† (VTI), Jerker Sundström (VTI)
Sources of funding Banverket, VTI
This is a collaboration between KTH and VTI (Swedish National Road and Transport Research Institute). The entire study is investigated in two phases. The first phase of the studies is completed on the real train environment, whereas the second part of the studies is made at the laboratory environment. The main objective of the project is to investigate the effects of vibration on the performance of various sedentary activities like reading, writing, drinking and computer works. In the first phase of the studies a questionnaire survey and vibration measurements were made on several aboard trains. Results of the studies are presented at international conferences.

The second phase included laboratory studies, where the effects of

low-frequency vibration (0.8 Hz to 10 Hz) on sedentary activities, namely reading and writing, are investigated in a mock-up carbody. This investigation is focused on continuous and transient vibration signals using various amplitudes and frequencies. The project was completed in 2006 with the Ph.D. thesis of Jerker Sundström.

Khan S and Sundström J, *Vibration measurements in Swedish Inter-City trains – Evaluation of discomfort values*, paper presented at the 12th International Congress on Sound and Vibration, Lisbon, 2005.

Sundström J, *How is train passengers' reading and writing influenced by occasional lateral acceleration peaks?*, paper presented at the 40th UK Conference on Human Response to Vibration, Liverpool,13-15 September, 2005.

Sundström J, Khan S and Andersson E, *Passagerares upplevelse av vibrationer på tåg – Är våra tåg komfortabla?*, Transportforum, Linköping, 11-12 januari 2006.

Sundström J, *Difficulties to read and write under lateral vibration exposure – Contextual studies of train passengers' ride comfort*, Ph.D. Thesis, TRITA AVE 2006:24, KTH Rail Vehicles, 2006.

Sundström J and Khan S M, *Train passengers' ability to read and write during lateral vibration transients*, paper presented at 13th International Congress on Sound and Vibration, Vienna, 2006.

Sundström J, *Lateral vibration and train passengers' activity comfort,* paper presented at the 41st UK Conference on Human Response to Vibration, Farnham, UK, 20-22 September, 2006.

6. Dynamic instability and discomfort of high-speed trains, in particular induced by aerodynamics in tunnels (SAMBA 9)

Researchers: Mats Berg, Sinisa Krajnovic (Chalmers), Ben Diedrichs
Sources of funding: Banverket, Bombardier Transportation
The main background for this project is the lateral dynamics problems encountered in Japan for some Shinkansen trains travelling through tunnels. In particular, the tail cars can oscillate heavily creating discomfort and a potential safety risk. So far no cases have been found in Europe with similar oscillating amplitudes and problems. Based on very computationally demanding aerodynamic simulations, it can be concluded that the most important parameters to explain the present phenomena are: ratio between train cross-section and tunnel cross-section, distance from train to tunnel wall, shape of the train tail and probably also on the inter-vehicle gap and bogie shielding. The practical results of the project are guidelines on how to design vehicles and tunnels to avoid the kind of problems described above. Vehicle-track interaction analysis, including aerodynamic external loads, are also included to further support these guidelines. In addition, crosswind effects have been merged into the project in recent years.

The project was in principle completed in 2006 with the Ph.D. thesis of Ben Diedrichs.

Krajnovic S, Hemida H and Diedrichs B, *Time-Dependent Simulations for the Directional Stability of High Speed Trains Under the Influence of Cross Winds or Cruising Inside Tunnels*, Fluid Dynamics Applications in Ground Transportation: "Simulation, a primary development tool in the Automotive industry", Lyon, France, 26-28 October 2005.

Diedrichs B, *Studies of two aerodynamic effects on high-speed trains: Crosswind stability and discomforting car body vibrations inside tunnels*, Ph.D. Thesis, TRITA AVE 2006:81, KTH Rail Vehicles, 2006.

Three more publications are pending (Paper C, F and G of the Ph.D. thesis above).

7. Green Train

Programme manager and research leader: Evert Andersson
Researchers: Shafiquzzaman Khan, Rickard Persson (VTI), Anneli Orvnäs
Sources of funding: Banverket, Vinnova
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 45 MSEK (5 MEUR) besides still higher contributions from industry (as decided at the end of 2006). The duration is at least from 2005 to 2010.

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

Andersson E, *Gröna tåget – fordonsteknik för framtiden*, Nordic Rail, Jönköping, 4-6 oktober 2005.

Andersson E, *Gröna tåget – vårt framtida höghastighetståg: Projekt och visioner, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.*

Besides programme management, the Division of Rail Vehicles at KTH contributes to the following fields:
Track-friendly bogies (Anneli Orvnäs and Evert Andersson)
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. In the summer 2006 these developments were successfully tested on various straight and curved tracks in Sweden.

Orvnäs A, *Utveckling av spårvänliga boggier för höga hastigheter – en simuleringsstudi*e, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

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

Persson R, *Korglutning, analys av dagens situation*, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

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

Khan S M, *Can A-weighted sound pressure level (LA) predict annoyance from railway noise? – A laboratory study,* 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

8. Robust safety systems for trains

Researchers: Evert Andersson, Dan Brabie
Sources of funding Banverket, Bombardier Transportation, SL AB, SJ, Green Cargo, Vinnova
This research project aims at systematically studying the possibilities of minimizing devastating consequences of high-speed derailments by appropriate measures and features in the train design. In particular the cause of events immediately after a mechanical failure on axles, wheels, rails or similar is studied, e.g. whether the train stays upright close to the track centre or deviates laterally with probably serious consequences. Conclusions are drawn from an interactive process where multi-body computer simulations are performed and compared with real incidents and accidents. Different train design parameters are systematically investigated by means of in this way validated simulation models. The

vehicle behaviour associated with derailments is taken into consideration through a newly developed multi-body system post-derailment module, capable of predicting the dynamic motion of wheelsets rolling and bouncing on concrete sleepers.

The project is estimated to continue at least to the end of 2007.

Brabie D, *On the influence of rail vehicle parameters on the derailment process and its consequences*. Licentiate Thesis, TRITA AVE 2005:17, KTH Railway Technology, Stockholm, 2005.

Brabie D and Andersson E, *Dynamic simulation of derailments and its consequences*, Proc. of the 19th IAVSD Symposium, pp. 652-662, Milan, Italy, 29 Aug – 2 Sep, 2005.

Brabie D and Andersson E, *Robust safety systems for trains – Dynamic simulations of derailments and its consequences*, 13:e Nordiska Seminariet i Järnvägsteknik, Hamar, Norge, 10-11 maj 2005.

Brabie D and Andersson E, *Train derailment studies by means of computer simulations – Methodology and applications*, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

Brabie D, *Wheel-sleeper impact model in rail vehicles analysis*, presented at the 3rd Asian Conference on Multibody Dynamics, 1 – 4 August, Tokyo, 2006.

9. Simulation of energy and running time of trains (SimERT)

Researcher: Piotr Lukaszewicz
Source of funding: Banverket
The aim of the project is to:
- Develop models of trains and drivers for calculation of power consumption, impact on environment, capacity and running time.
- Perform research on how the energy usage and running time of trains is affected in particular by the driving style and train characteristcs.
- Develop optimised driving strategies in a rail network with respect to energy usage and driving time, so called eco-driving.

Computer models of trains and drivers are developed from full-scale measurements and thereafter verified. The driver computer models can drive a train in a similar way as an average driver would do, by making use of developed driving describing parameters. It is also possible to drive in any desired way, so that optimized style of driving can be tested with respect to energy usage, impact on environment, capacity and time table.

The project will run for 2005-2008.

Lukaszewicz P: *Impact of train model variables on simulated energy usage and journey time*. Proc. of COMPRAIL X, Prague, Czech Republic, 2006.

Andersson E, Lukaszewicz P och Larsson C, *Högre hastighet med lägre energiåtgång – En studie av energiförbrukning för moderna tåg*, 14:e Nordiska Seminariet i Järnvägsteknik, Linköping, 26-27 april 2006.

Andersson E and Lukaszewicz P, *Energy consumption and related air pollution for Scandinavian electric passenger trains*, TRITA AVE 2006:46, KTH Rail Vehicles, 2006. In collaboration with and partly funded by Bombardier Transportation.

10. Nowait Transit

Researcher: Mats Berg (KTH part)
Source of funding: Botnia Production (Vinnova)
A new mass transit vehicle concept is proposed in this project. On elevated guideways in big cities, very long trains with short carbodies will fold and at the same time slow down when approaching stations. Passengers can exit from and enter into the cars while the trains are moving very slowly through the stations. When leaving the stations, the trains unfold and speed up again. The KTH part in the overall project is mainly on the mechanical train design and the train-track interaction. The KTH part of the project is completed.

11. Efficient train systems for freight transportation

Researchers: Evert Andersson (for the part of Rail Vehicles), Sebastian Stichel, Per-Anders Jönsson, Rune Bergstedt
Sources of funding: Banverket, Vinnova, Green Cargo
This is a multidisciplinary project, aiming at finding means to develop rail freight systems. It is a systems study on technology, procedures market and economy.

The project includes several parts. The Division of Rail Vehicles has mainly participated in the parts on Intermodal transports, Dual Mode Locomotives, Vehicle-track Interaction as well as Running Gear and Braking. The project was completed in 2005.

Jönsson P-A, *Löpverk för högre axellast och hastighet*, Rapport 0506B, Järnvägsgruppen KTH, 2005.

Stichel S, *Ökade laster med hänsyn till spårnedbrytning*, Rapport 0506C, Järnvägsgruppen KTH, 2005.

Bergstedt R, *Automatkoppel,* Rapport 0507, Järnvägsgruppen KTH, 2005.

Bergstedt R, *Bromssystem*, Rapport 0508, Järnvägsgruppen KTH, 2005.

Bergstedt R, *IT-teknik för effektiva tågsystem för gods – Intelligenta informationssystem*, Rapport 0509A, Järnvägsgruppen KTH, 2005.

Bergstedt R, *IT-teknik för effektiva tågsystem för gods – Fördelad dragkraft och fjärrstyrda lok,* Rapport 0509B, Järnvägsgruppen KTH, 2005.

Skoglund M, *Dual-mode locomotives – a systems study*, M.Sc. Thesis, TRITA AVE 2005:49, KTH Railway Technology, 2005.

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

Researchers: Mats Berg, Shafiquzzaman Khan, Mats Åbom et al.
Source of funding: European Commission.

This is an EU-Asia link project for 2006-2008 involving KTH, Loughborough University, IIT Roorkee and IIT Delhi. The project aims at carrying out research and education activities within the field of sound and vibration. The research work is on ride comfort in trains and from a KTH perspective it can be considered a continuation of the SAMBA 8 project, cf. above. The education part is on developing courses and methods of teaching related to sound and vibration; here KTH MWL is heavily involved. The project also includes five short courses given in India, and a student mobility part mainly giving 12 Indian students the possibility to study at KTH or Loughborough University for 6–24 months.

Gupta M, *Simulation and visualization of various acoustic sources in MATLAB*, Summer Internship Project, Report, KTH, July 2006.

Mansfield N J (ed.), *Literature review on low frequency vibration comfort*, Loughborough University, UK, 2006. KTH Rail Vehicles contributed to this publication.

14. Train Information Management and Monitoring (TIMM)

Researcher: Stefan Östlund, Mats Berg, Tobias Forsberg, Fredrik Carlsson
Source of funding: Vinnova, Banverket, Bombardier Transportation, Tågoperatörerna, SKF
This is a two-year project (2006-2007) carried out by KTH and Swedish Institute of Computer Science (SICS).
The pressure on the railways to provide more flexible and efficient rail transportations makes it necessary to develop tools for common status information, deviation detection, prognoses, dynamic re-planning and optimisation. Such tools facilitate e.g. condition monitoring of vehicles and infrastructure via sensors in the vehicle or in the infrastructure. The proposed project deals with the process of designing a platform for information management and monitoring of trains. The project consists of four work packages: WP1 Condition Monitoring, WP2 Diagnosis and deviation detection, WP3 Dynamic re-planning, WP4 Information platform issues. The work of Div. of Rail Vehicles is mainly within WP1 and deals with monitoring of railway mechanics. Up to now the dynamics of train ride stability has been investigated.

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

15. Crosswind stability and unsteady aerodynamics in vehicle design

Researchers: Mats Berg, Dirk Thomas, Ben Diedrichs et al.
Source of funding: Vinnova, Banverket, Bombardier Transportation, Vägverket, Scania, Saab Automobile.
This is a project for 2006-2010 within the new Vinnova Centre of Excellence ECO2 Vehicle Design at KTH Aeronautical and Vehicle Engineering. ECO2 stands for ECOnomical and ECOlogical and the centre both deals with rail and road vehicles.

Ground vehicles are subject to various wind conditions such as crosswinds that can cause vehicle instability and severe accidents. This is particular true for lightweight vehicle designs with substantial height and during conditions with limited payload. The increasing number of rail/road bridges and embankments also makes the crosswind as well as its consequences more pronounced.

A further complication is that the atmospheric (cross)wind can be gusty causing dynamic vehicle loading and unsteady response. Moreover, even in steady free field wind conditions the vehicles experience a time-dependent loading when travelling from a forest or tunnel out to a more open landscape. Also at opposing traffic and overtaking, sensitivity of crosswind effects can be severe especially between passenger cars and trucks.

Taken together, ground vehicles sensitive to wind gusts constitute a safety risk and the road vehicle driving can become tiring. For high-speed trains the issue of crosswind safety will be introduced in European legislation. But improved computer hardware/software performance facilitates an increase in knowledge of the present topic and will provide a basis for more realistic dynamic simulations of the aerodynamic loading and the dynamic vehicle response, and thus less wind sensitive vehicle designs and better requirements/legislations are possible.

Given this background, a first goal of this project is to achieve an enhanced understanding of unsteady crosswind and the resulting vehicle response. Based on these findings a second goal is to suggest less wind sensitive vehicle designs in terms of modifying the external shaping, mass properties and suspension characteristics. A third goal is to improve the driver-vehicle interaction at crosswind gust situations. Some proposals on wayside crosswind condition monitoring and modified rail/road infrastructure designs are also foreseen. To some extent also the potential of onboard crosswind (response) condition monitoring to support decisions on speed reductions and road vehicle handling are included. Later on also active suspension designs should be studied in this context.

2.2 Transportation and logistics

The Group has special competence in the areas of traffic planning, customer preference evaluations, models for explaining the number of passengers, capacity simulation models, logit models and travel time evaluations.

Personnel

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M.Sc. course

Rail Traffic Planning: 5 credits (1H1206)

Ph.D. course

Methods for Rail Traffic Planning: 5 credits (F1N5200)

RESEARCH PROJECTS

Freight and logistics

1. Efficient train systems for rail freight transportation – a system study

Researchers: Bo-Lennart Nelldal, all members of KTH Railway Group, Peter Bark (TFK) and Jakob Wajsman (Banverket)
Sources of funding: Swedish National Rail Administration (Banverket) and Vinnova. Duration: 1999-2005
An interdisciplinary study involving all members of the Railway group. The idea was to look at the railway as a system both from the market and from the technical point of view, competing and cooperating with other modes. The aim of the study was to describe how the future rail freight transportation system can be designed, depending on the potential technical development of the railway, the market and the customers' demands and preferences.

The critical factors were defined from the market point of view. The possible future performance of the railways was analysed on the basis of available techniques and applications in different products, for example, in wagon-load, inter-modal and high-speed freight systems. An evaluation from the business point of view has been conducted for

different products. A forecast of the effects on the Swedish transport market of implementation of the ideas for efficient freight train systems in 2020 has also been carried out. Finally, some important strategic factors, relevant for further research and development were described.

Effektiva tågsystem för godstransporter. Sammanfattning (folder). KTH Järnvägsgruppens rapport 0502. 2005

Efficient train systems for freight transport. Summary (folder). KTH Railway group report 0503. 2005

Nelldal B-L (red), *Effektiva tågsystem för godstransporter – en systemstudie. Huvudrapport*. KTH Järnvägsgruppens rapport 0504, 2005.

Nelldal B-L (ed.), *Efficient train systems for freight transport – A systems study. Principal report*. KTH Railway group report 0505, 2005.

Östlund et al, *Fordon och infrastruktur för effektiva godstransporter.* KTH Järnvägsgruppens rapport 0506, 2005.

Bark P, *Effektiva tågsystem för vagnslast- och systemtåg*. KTH Järnvägsgruppens rapport 0510, 2005.

Wajsman J, *Transportmarknadens struktur och järnvägens konkurrenskraft.* KTH Järnvägsgruppens rapport 0511, 2005.

Troche G, *High-speed rail freight.* KTH Järnvägsgruppens rapport 0512, 2005.

Nelldal B-L, Bark P, Wajsman J och Troche G, *Konkurrenskraftiga kombitransporter.* KTH Järnvägsgruppens rapport 0513, 2005.

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

Researchers: Bo-Lennart Nelldal, Gerhard Troche
Sources of funding: Swedish National Rail Administration (Banverket) and Green Cargo (Swedish State Freight Railways) Duration: 1998-2007.

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 to get input data for forecast-models and for calculations of new transport-systems. The model is an activity based cost model (ABC) that also increase understanding of how costs is generated and of cost-drivers.

With the model it will be possible to calculate the effects of new transport systems and changes in performance in the railway system. Examples are higher axle-loads, wider structural gauge, longer trains, automatic couples and new traffic patterns. The model has among others been used to evaluate new train concepts in the project "Efficient train systems for rail freight transportation".

3. Freight customers' valuations of factors of importance in the transportation market

Researchers: Bo-Lennart Nelldal, Sofia Lundberg
Sources of funding: Swedish National Rail Administration (Banverket) and Green Cargo (Swedish State Freight Railways). Duration: 2002–2008.

The purpose of this project was to determine the freight customers' valuations important to their choice of transport mode for long-distance freight transportation. The results are intended to form the basis for valuations of changes in the transport system and for forecast models. The purpose was to study the general valuations of certain quality factors that transportation buyers have regardless of the type of transportation. The study covered all transport modes and transportation systems.

The method used was computer-assisted telephone interviews that were conducted by the author with slightly fewer than 100 transportation managers and a response frequency of 99%. The results show that transportation cost is a very important factor when choosing a carrier. Actual transportation in today's transport systems is of high quality with few delays and little freight damage At the same time, the transportation market is subject to stiff competition, which is one of the reasons why transportation customers are sensitive to price. The threshold for switching carrier is on average a 3.8% lower price, even with everything else unchanged. The companies use many transportation companies. Almost all of them use more than one and over half use more than 10.

The results has been published in a licentiate-thesis. The project is planned to continue with further analyses.

Lundberg S, *Godskunders värderingar av faktorer som har betydelse på transportmarknaden*. Licentiatavhandling TRITA-TEC-LIC 06-001, 2006.

4. Evaluation of intermodal transport chains

Researchers: Bo-Lennart Nelldal, Sofia Lundberg (KTH), Ulf Carlsson (KTH-MWL), Peter Andersson (Mariterm), Peter Bark (TFK) et al.
Sources of funding: Swedish National Road Administration (Vägverket) and Swedish National Rail Administration (Banverket) by SiR-C (Swedish Intermodal Transport Research Center. Duration: 2006-2008.

Intermodal transport chains includes several modes and terminal handling which means a specific cost, time and eventual damage on the goods transported. The aim of this project is to follow some intermodal chains and to investigate each link in the chain as concern time, cost and possible damage. The aim is to find the weakest link in an intermodal transport chain that can be critical to increase combined transports.

Different transport chains will be chosen with different modes, terminal handling and distance. Measures can be made by instruments on a container, swap-body or trailer registering time, temperature and vibrations. The data will be stored and transmitted by cellular phone. Also the administrative process will be investigated.

5. Effects of distance-based road-user fees for trucks

Researchers: Bo-Lennart Nelldal, Gerhard Troche (KTH) and Jakob Wajsman (Banverket)
Sources of funding: Vinnova. Duration: 2005–2007.

Distance-based road-user fees for trucks have been introduced in some European countries and may also be introduced in Sweden. The aim of this project is to analyse how the fees will affect the modal split between road and rail transport. This will be done with empirical data from Europe as well as with forecast models for Sweden. Different scenarios will be defined which depends on the level of the fees and the actual road network and also in combination with stimulation for new transport on rail that also exist in some countries.

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

6. Projects within SiR-C

KTH Railway Group is participating in the virtual research center SiR-C (Swedish Intermodal Transport Research Center) together with Chalmers University of Technology (CTH), School of Business Economics and Law at Gothenburg University (HGU), Transport Research Institute (TFK), MariTerm, Transek-WSP and BMT Transport Solutions.

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

7. New Opera och FERRMED

New Opera and FERRMED are both EU-projects dealing with future rail freight transport corridores in Europe. New OPERA stands for New European Wish: Operating Project for a European Rail Network and is a Coordinated Action in the area of joint European railway research. New OPERA will study the necessary step changes for achieving a long-term scenario 2020 of a core network predominantly dedicated to rail freight. FERRMED is a private organisation to promote freight railways axis in Scandinavia-Rhine-Rohne-Western Mediterranean. Bo-Lennart Nelldal is member of the scientific committee of New Opera project and Gerhard Troche is member of the advisory board of FERRMED.

Passenger transport and customer preferences

1. Gröna tåget – market and services subproject

Researchers: Oskar Fröidh, Bo-Lennart Nelldal, Johannes Wolfmaier, Hans Sipilä, Ana Rivas

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2005–2008.

The aim of the research program Gröna tåget (Green train) is to strengthen the 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.

Market and services for the Gröna tåget will be a frame for many technical and economic issues. One important task is to set a platform for an internationally viable knowledge-base of train concept design. The market and services section has the aim to design a concept for the new train with high customer values, i.e. to identify new market segments for services and to work out a suitable performance specification and layout with respect to customer valuations and travel demand.

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

Market and services working team are expected to present a report, which will be a foundation for design of the concept of the Gröna tåget. The intention is to present the results as a specification of requirements.

Fröidh O, *Gröna tåget. Framtida tågprestanda och bangeometri.* KTH, PM 2005.

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

Researchers: Bo-Lennart Nelldal, Sara Björlin Lidén (Transek), Oskar Fröidh (KTH), from Transek AB: Göran Tegnér, Cristian Nilsson and Stefan Persson

Source of funding: Vinnova and Alstom Transport AB. Duration: 2006-2007

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

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

Fröidh O, *Modelling operational costs of a future high-speed train. Proceedings of the CIT 2006 conference,* Ciudad Real, Spain, 2006.

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

Researchers: Oskar Fröidh, Karl Kottenhoff

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2006-2008.

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

The research project will be carried out as a case study of the Blekinge Coast line before and after the introduction of electrical regional trains. The scope is interviews with travellers including RP and SP, and also collection and analyses of bus and train supply and travel demand data. The results will be connected to a forecast model in case of large supply changes. A final report will be published in 2008.

4. Establishing regional train services – a comparison between regions – introductory study

Researcher: Oskar Fröidh

Source of funding: Swedish National Rail Administration (Banverket)

Duration: 2004-2005

This research project aims at improving the possibilities for regional train services in the context of urban and regional planning. The project includes analyses of different regional traffic systems with different train service supplies in regions with varying socio-economic prerequisites and labour markets. The study of markets for regional train services concentrates on geographical differences between regions in Sweden.

Fröidh O, *Market effects of regional high-speed trains on the Svealand line.* Journal of Transport Geography 13 (4), 352-361, 2005.

5. Car ownership model considering accessibility and public transport supply

Researchers: Bo-Lennart Nelldal, Oskar Fröidh, Staffan Algers (Transek AB), from the consultant Transek AB as well as Isak Jarlebring and Joakim Köhler

Source of funding: Swedish National Rail Administration (Banverket). Duration: 2003–2007.

Access to a car is an important factor when considering choice of mode for travelling. In the national forecast system, SAMPERS, an older car ownership model was implemented, which, especially for urban areas with a good public transport supply, has proved to be inaccurate. This project aims to develop a new car ownership model based on

accessibility measures and with respect to the public transport supply for different regional structures.

KTH and Transek finished a research project funded by the Swedish National Rail Administration in 2005. In 2006 an application has been submitted to continue developing the model in to a fully tested an implemented part of the national prognosis system Sampers.

6. Public transport worth its price – effects on regional commuting

Researchers: Karl Kottenhoff, Oskar Fröidh, Kjell Jansson (KTH/ÅF). From the consultant ÅF also Chris Halldin
Source of funding: Vinnova. Duration: 2004-2007.
This project aims to show how reduced generalised travel costs for public transport contribute to enlarging the regional labour market in the Stockholm and Mälardalen regions. The following goals are important: a higher employment rate, a higher competence provision and reduced social costs. Means to reaching these goals are: Reducing travelling times, increasing and levelling out travelling comfort for trips across the county border, and adjusting the price structure to reduce great cost differences.

These measures increase accessibility to public transport and can reduce car traffic. In this way, economic growth and environmental sustainability can be promoted. The results are presented as generalised costs, regional distribution, accessibility, financial effects, externalities, social economics, social distribution effects and potential for growth. Moreover, more specific issues have come to light, for example, the value of the ability to work during a commuting trip. The project consists of four studies:

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

7. Monetary valuation of ride comfort related to track quality

Researchers: Karl Kottenhoff, Jerker Sundström, Birgitta Thorslund (VTI), Camilla Byström (Transek AB)
Source of funding: Swedish National Rail Administration (Banverket). Duration: 2001–2007.
The purpose of this study is to quantify train passengers' ride comfort with respect to track maintenance. How much are passengers willing to pay for a higher standard? The project consists of two parts. The first part is a perception study that will show how passengers perceive train comfort. In the second study, the train passengers' willingness to pay for maintenance comfort will be estimated. The project is being done in cooperation between KTH, VTI and Transek AB.

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

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

On behalf of Banverket the department of Transportation and Logistic has continuously built up a database of supply and prices for 56 railway lines in Sweden. The database now consists of the years 1990-2005 and will be updated every year. The content is facts about travel times, frequences 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. A report twill be published every second year that also include an analysis of competition between train operators and between rail, air, bus and private car.

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

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

Capacity analysis and simulation

1. Capacity for passenger and freight traffic on single track – simulation of different traffic patterns on the Bothnia rail-link between Sundsvall and Umeå

Researchers: Bo-Lennart Nelldal, Anders Lindahl
Source of funding: Swedish National Rail Administration (Banverket)
Duration: 1999-2006
The Railway Group at KTH has previously made an analysis of future operation principles with new vehicle concepts. One concept is to have many short trains instead of just a few long trains, where some trains go directly to their destination and others stop more often.

The study concludes that the demand for service and the increased traffic will create new and variable demand for infrastructure. It will, thus, be desirable to have a stable infrastructure, which will pave the way for a flexible traffic system. The aim of this project is to analyse, with the simulation model RailSys, different traffic principles and the construction of new infrastructure to achieve as much flexibility and as few delays as possible.

2. Future infrastructure and train run quality

Researchers: Bo-Lennart Nelldal, Olov Lindfeldt
Source of funding: Swedish National Rail Administration (Banverket)
Duration: 2004-2008.
This project has two major parts: capacity design of single-track railways and capacity design of double-track. The punctuality, i.e. delay distributions, and train run quality, are important factors in both parts. The two parts together will form a Ph.D. thesis.

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

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

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

3. Simulation and capacity analysis

As a result of cooperation with IVE (The Institute of Transport, Railway Construction and Operation) at the University of Hannover KTH has availability to the simulation software Railsys. This model has been developed with great efforts in many years and is used in many countries around the world. Railsys is commercially handled by RMCon (Rail Management Consultants).

In the simulation model the infrastructure with all tracks and signalling blocks will be defined as well as the time table and the vehicles (trains). The result shows how a given line and time-table will handle e.g. delays.

Banverket has in 2006 chosen Railsys for their future work. The Railway Group is also sub-contractor of Railsys in Sweden and offer support and education of Railsys in Sweden. A user group will be formed to exchange experience.

The Railway Group also offers commision in capacity analysis and simulation. Simulation has been carried out of the following railway lines: "Ostlänken" Stockholm–Linköping, "Svealandsbanan" Stockholm–Eskilstuna, "Nynäsbanan" Västerhaninge–Nynäshamn, "Västra stambanan" Stockholm–Järna.

Fröidh O, Lindfeldt O, Nelldal B-L, *Framtida marknad, tågtrafik och kapacitet inom Stockholms Central*. KTH TRITA-INFRA 05-010, 2005.

Fröidh O, Jansson T, *Kapacitetsanalys av två principutformningart av bansystemet på Ostlänken*. KTH TRITA-INFRA 05-017, 2005.

Wahlborg M, Jansson T, *UIC capacity management methods – the Mälar line case*. TRITA-INFRA 05-009. 2005.

2.3 Lightweight Structures

(No railway activities during 2005-2006.)

2.4 Structural Design and Bridges

The division is conducting research and education within railway track engineering including bridges and tunnels. They are also responsible for co-ordination of issues concerning the railway infrastructure.

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M.Sc. Courses

Rail Track Engineering: 5 credits (1C1206)
Road and railway track engineering: 5 credits (1L1913)
Structural Dynamics for Civil Engineers: 5 credits (1L1032)

RESEARCH PROJECTS

1. Loads and Load Influence on Structures

Researchers: Raid Karoumi and Gerard James
Source of Funding: Johnson Foundation, KTH, Swedish National Road Administration (Vägverket), Swedish National Rail Administration (Banverket).
The project deals with studies of the dynamic response of bridges subjected to moving vehicles. Measurement methods for loading on railway and road bridges are examined. Bridge weigh-in-motion systems including interpretation of statistical results are developed.

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

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

2. Long-term Monitoring and Assessment of Bridges

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

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

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

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

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

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

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

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

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

Researchers: Raid Karoumi and Johan Wiberg
The New Årsta Railway Bridge in Stockholm is a slender and a very complex prestressed concrete structure. Over 80 sensors, e.g. traditional strain gauge and fibre optic sensors, are embedded into the concrete section to monitor strains that arise from curing concrete, dead load, traffic, wind. The Swedish National Railway Administration (Banverket) initiated the measuring program to follow up stresses and deformations during construction and operation of the bridge. The dynamic and static behaviour of the bridge is investigated through inspection and supervision via internet connection to the sensors, which will give a unique opportunity for research on railway bridges and particularly the interaction between trains and the bridge.
The objective is to verify uncertainties in the structure, during construction and 10 years of service, leading to knowledge and updated codes which, in turn, will give economical and safe solutions concerning similar structures in the future. The aim is to:

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

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

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

4. Efficient train systems for rail freight transportation

Research leader Håkan Sundquist, Research assistant Gerard James
The report has been presented as a part of the report "Efficient train systems for freight transportation"

5. Sustainable bridges

Researchers: Håkan Sundquist, Raid Karoumi and Gerard James
The project is a European Community funded project that involves the cooperation between many partners from universities, railway infrastructure owners and industry around Europe and is part of the sixth framework programme.
The aim of the project is to produce guidelines and research papers to assist engineers in the evaluation of existing railway bridges. Much of the railway bridge stock in Europe is coming to an end of its originally planned service life, however, the demands on our railway bridges are constantly increasing with railway operators requiring increased allowable axle loads and increased train speeds. There is a common European need to establish new and improve existing methods for the evaluation of this ageing railway bridge stock.

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

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

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

6. Soil-Structure Interaction for Integral Bridges and Culverts

Researchers: Håkan Sundquist and Esra Bayoglu

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

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

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

Researchers: Raid Karoumi, Johan Wiberg and Mahir Ülker

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

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

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

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

8. Bridge Weigh-in-motion for railway bridges

Researchers: Raid Karoumi and Axel Liljencrantz

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

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

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

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

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

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

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.

2.5 Marcus Wallenberg Laboratory for Sound and Vibration Research

The laboratory is, within the KTH Railway Group, responsible for issues concerning noise and vibration in railway engineering. The research group has a long and broad experience of the field including internal as well as external noise and vibration.

Personnel

Professors	Mats Åbom Ph.D.	matsabom@kth.se
	Leif Kari Ph.D.	leifkari@kth.se
Associate professor	Leping Feng Ph.D.	fengl@kth.se
Researchers	Ulf Carlsson Ph.D.	ulfc@kth.se
	Kent Lindgren	kent@kth.se

RESEARCH PROJECTS

1. Gröna Tåget – noise and vibration part

Researchers: Ulf Carlsson, Leping Feng, Mats Åbom, Leif Kari, Shafiquzzaman Khan

Sources of funding: Banverket, Bombardier Transportation et al

The noise and vibration part of the project involves three subtasks, – to identify the aspects of railway noise that cause annoyance, – to investigate the possibilities to use a low, near-track rail-mounted screen to reduce the external noise radiation and – to investigate the structure-borne sound transmission from the wheel-rail contact region to the coach interior.

2.6 Electrical Machines and Power Electronics

The laboratory for Electrical Machines and Power Electronics at the School of Electrical Engineering carries out research and education in the field of electric railway traction. That includes traction motors, transformers, converters and electromechanical devices.

Personnel

Professor	Stefan Östlund Ph.D.	stefan.ostlund@ee.kth.se
Scientists	Staffan Norrga Ph.D.	norrga@kth.se
	Juliette Soulard Ph.D.	juliette.soulard@ee.kth.se
	Fredrik Carlsson Ph.D.	fredrikc@ee.kth.se
Graduate students	Tommy Kjellqvist MSc	tommy.kjellqvist@ee.kth.se
	Mattias Skoglund MSc	mattias.skoglund@tfk.se

M.Sc. Course

Electric Traction: 4 credits (2C1149)

RESEARCH PROJECTS

1. New converter topologies for electric railway traction

Researchers: Stefan Östlund, Staffan Norrga, Tommy Kjellqvist

Sources of funding: Banverket, KTH Railway Group

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

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

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

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

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

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

Researchers: Stefan Östlund, Mattias Skoglund

Source of funding: Banverket and VINNOVA

The project is carried out in cooperation with TFK. It consist of two parts. The objective of the first part is to develop a specification for a dual-system freight locomotive. That is, a train with both a diesel engine and electrical supply. In the project has been studied both the design of the locomotive an its impact on the operation regarding for instance energy consumption, logistics and emissions. The objective of the second part is to study drive cycles for freight locomotives. Better drive cycles are required for a more accurate evaluation of different locomotive concepts.

3. System aspects of Permanent magnet traction motors

Researcher: Juliette Soulard

Source of funding: Banverket/Gröna Tåget

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

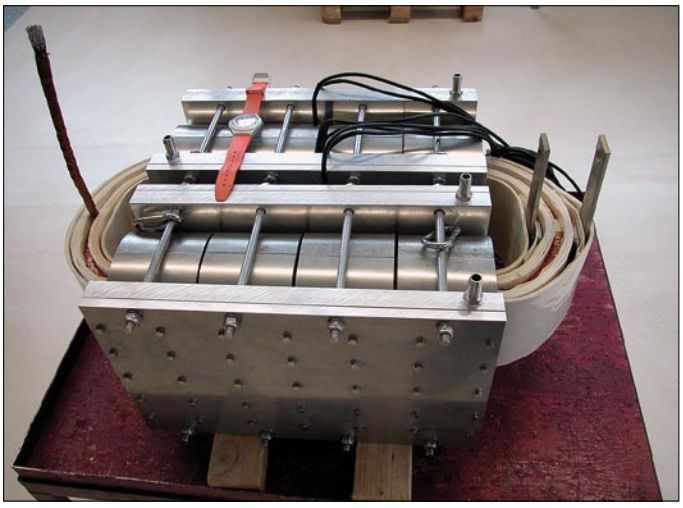
4. Train Information Management and Monitoring (TIMM)

Researcher: Stefan Östlund, Mats Berg, Tobias Forsberg, Fredrik Carlsson

Source of funding: Vinnova, Banverket, Bombardier Transportation, Tågoperatörerna, SKF

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

Today the European railways are being deregulated and massive sums are invested in new infrastructure thus rail transportation is expected to increase considerably. The pressure on the railways to provide



more flexible and efficient rail transportations makes it necessary to develop tools for common status information, deviation detection, prognoses, dynamic re-planning and optimisation. Such tools facilitate e.g. condition monitoring of vehicles and infrastructure via sensors in the vehicle or in the infrastructure. The proposed project deals with the process of designing a platform for information management and monitoring of trains. The project consists of four work packages: WP1 Condition Monitoring, WP2 Diagnosis and deviation detection, WP3 Dynamic re-planning, WP4 Information platform issues. The work of the laboratory for electrical machines and power electronics is mainly within WP1 and deals with monitoring of the propulsion and in particular the current collection. Up to now the dynamics of train ride stability has been investigated.

2.7 Machine Elements

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.

Personnel

Professor	Ulf Olofsson Ph.D.	ulf.olofsson@itm.kth.se
Graduate student	Jon Sundh M.Sc.	sundh@md.kth.se
Research engineer	Krister Sundvall M.Sc.	kristers@md.kth.se

RESEARCH PROJECTS

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

Researchers: Ulf Olofsson, Jon Sundh, Krister Sundvall

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

Delicado B, *Wear/Damage mapping in the wheel-rail contact*, Master of Science thesis KTH Industrial Engineering and Management 2005.

Olofsson U, Lewis R, *Wheel and rail material wear mechanisms and transitions*, IRG-OECD Meeting June 13-14 2005 Uppsala Sweden.

Andersson S, Olofsson U, *Towards a general model for wear simulation,* IRG-OECD Meeting June 13-14 2005 Uppsala Sweden.

Sundh J, Skytte af Sätra U, *Influence of surface topography and remelting on seizure initiating in lean lubricated sliding contacts*, IRG-OECD Meeting June 13-14 2005 Uppsala Sweden, accepted for publication in Wear.

Olofsson U, Lewis R, *Tribology of the wheel-rail contact*, in A Handbook of Railway Vehicle Dynamics ed. S. Iwnicki, Swets & Zeitlinger Publishers (2006).

Sundh S, Olofsson U, 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*, CM2006 in Brisbane (2006).

Sundh J, Olofsson U, *Seizure mechanisms of wheel/rail contacts under lubricated conditions using a transient ball-on-disc test method*, June 7-9, Nordtrib 2006 Helsingör.

M B Marshall, R Lewis, R S Dwyer-Joyce, U Olofsson, S Björklund, *Experimental characterization of wheel-rail contact patch evolution*, JOURNAL OF TRIBOLOGY-TRANSACTIONS OF THE ASME 128 (3): 493-504 JUL 2006.

2. Leaf lubrication between railway wheel and rail

Researchers: Ulf Olofsson, Krister Sundvall

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 10000 and 50000 leaves. There are estimations that thousands of tonnes of leaves fall onto railway lines every year. The leaves are usually swept onto the track by the slipstream of passing trains. While conditions leading to poor adhesion have been well investigated, methods for addressing the problems have not. The purpose of this project is firstly to develop a test method where friction modifiers can be evaluated in contact conditions and an environment that correspond to the wheel rail contact. Secondly, the research aims to develop new environmentally friendly friction modifiers and, furthermore, to develop adhesion models for the railway wheel rail contact including contaminants.

Olofsson U, *Influence of natural (leaf and humidity) and applied lubrication on friction in the wheel–rail contact*, IMECHE LECTURE London 13th Mars 2006.

Olofsson U, *A multilayer model of leaf lubrication between railway wheel and rail*, accepted for publication 2006.

3. Airborne particles generated from train-track interaction

Researchers: Ulf Olofsson, Krister Sundvall

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

Olofsson U, Olander L, *On airborne wear particles generated from a steel on steel contact – a pin-on-disc simulation*, accepted for publication 2006.

2.8 Vehicle Dynamics

The group has a general interest in vehicle dynamics for ground vehicles. In railway research the focus is on the interaction between pantograph and the overhead catenary system.

Personnel

Assistant professor	Lars Drugge Ph.D.	larsd@kth.se
Graduate students	Pia Harèll Lic. Eng.	harell@kth.se
	Marten Reijm M.Sc.	marten.reijm@banverket.se

RESEARCH PROJECTS

1. Overhead power systems for interoperability of high-speed trains
Researchers: Lars Drugge, Annika Stensson, Pia Harèll, Marten Reijm
Source of funding: Banverket
To enable high-speed train operation within Europe (interoperability), there are high demands on safe and uninterrupted traffic. Interoperability implies that the same pantograph will operate on both AC and DC lines, with different designs of overhead power systems.

Today, pantographs designed for these lines are characterised by vast differences in mass, stiffness and damping. To enable better performance, future pantographs will probably be equipped with active components to be able to control the contact force.

There will also be different demands on high-speed lines, upgraded lines and connecting lines. The mean contact force, standard deviation and amount of contact loss depend on several factors, such as the design of the overhead power system and pantograph, the train speed and the aerodynamic conditions.

As a consequence, it will be important to be able to evaluate and recommend actions to be taken in order to offer a secure and uninterrupted operation on a specific track. One of the demands on the certified lines for high speed is that they need to be compatible with the power systems of the trains.

To facilitate the handling of these complex problems, the aim of this project is to continue the development of the simulation tool that is used today at Banverket, so that it also includes the possibilities to evaluate these aspects connected to interoperability.

Also, this implies a need for enhanced knowledge and understanding of effects caused by different pantograph designs.

Harèll P, Drugge L, Reijm M, *Study of critical sections in catenary systems during multiple pantograph operation*. Proc. IMechE Vol. 219 Part F: J. Rail and Rapid Transit (2005), p. 203-211.

3. Graduate degrees

3.1 Ph.D. degrees

In 2005 Rickard Nilsson, Department of Machine Design, defended his Ph.D. thesis *On wear in rolling/sliding contacts*.

In May 2005 Staffan Norrga, Electrical Machines and Power Electronics defended his Ph.D. thesis *On Soft-Switching Isolated AC/DC Converters without Auxiliary Circuit*.

In June 2006 Jerker Sundström, VTI and Div of Rail Vehicles, defended his Ph.D. thesis *Difficulties to read and write under lateral vibration exposure – Contextual studies of train passengers' ride comfort.*

In November 2006 Ben Diedrichs, Div. of Rail Vehicles, defended his Ph.D. thesis *Studies of two aerodynamic effects on high-speed trains: Crosswind stability and discomforting car body vibrations inside tunnels.*

In December 2006 Roger Enblom, Div of Rail Vehicles, defended his Ph.D. thesis *On simulation of uniform wear and profile evolution in the wheel-rail contact.*

3.2 Licentiate of Engineering degrees (Lic Eng)

In april 2006 Sofia Lundberg presented her licentiate thesis *Freight customers' valuations of factors of importance in the transportation market.*

In June 2005 Eric Berggren, Banverket and Div of Rail Vehicles, presented his licentiate thesis *Dynamic track stiffness measurement – A new tool for condition monitoring of track substructure.*

In June 2005 Dan Brabie, Div of Rail Vehicles, presented his licentiate thesis *On the influence of rail vehicle parameters on the derailment process and its consequences.*

4. Courses

4.1 M.Sc. Courses

RAIL VEHICLES

Railway Systems and Rail Vehicles: 6 credits (4B1304/4B4304)

Rail Vehicle Dynamics: 5 credits (4B1313/4B4313); the course is given in English

Rail Traffic Planning: 5 credits (1H1206)

Electric Traction: 4 credits (2C1149)

Rail Track Engineering: 5 credits (1C1206)

Road and railway track engineering: 5 credits (1L1913)

Structural Dynamics for Civil Engineers: 5 credits (1L1032)

4.2 Ph.D. Courses

Methods for Rail Traffic Planning: 5 credits (F1N5200)

5. External Courses

During the years 2005 and 2006 the following external courses have been given:

1. Track-Vehicle Interaction. A one-day course given for railway engineers at Banskolan, Ängelholm in February 2005. 10 participants. Evert Andersson.

2. Rail Vehicles and Vehicle-Track Interaction. A course given for students of the programme Railway Engineer (LTH, Banskolan), Ängelholm and Stockholm, six days in April-May 2005 and six days in April-May 2006. 8 + 11 participants. Evert Andersson, Mats Berg, Sebastian Stichel.

3. Track-Vehicle Interaction. A course given for railway engineers as part of Nordisk Banteknisk Ingenjörsutbildning (NBIU), Tällberg, two days in September 2005 and two days in October 2006. 24 + 25 participants. Evert Andersson.

4. Track-Vehicle Interaction. One-day courses given for railway engineers at Banskolan, Ängelholm in February and September 2006. 9 + 10 participants. Evert Andersson.

5. Safety Aspects of Rail Vehicles. A half-day course given for an international auditorium at Banskolan, Ängelholm in March 2006. 24 participants. Evert Andersson.

6. Electric Railway traction. One-day courses as part of Nordisk Elteknisk Ingenjörsutbildning (NEIU) in Tampere Finland in November 2005 and November 2006, 25 + 28 participants. Stefan Östlund.

6. Publication list

(Publications not related to specific projects)

6.1 Dissertations

Norrga S, *On Soft-Switching Isolated AC/DC Converters without Auxiliary Circuit.* Ph.D. thesis KTH. Ph.D. thesis, Electrical Machines and Power Electronics, KTH 2005.

Nilsson R, *On wear in rolling/sliding contacts* TRITA MMK 2005:03, Ph.D. thesis, Machine Design KTH 2005.

Sundström J, *Difficulties to read and write under lateral vibration exposure – Contextual studies of train passengers' ride comfort*, Ph.D. Thesis, TRITA AVE 2006:24, KTH Rail Vehicles, 2006.

Diedrichs B, *Studies of two aerodynamic effects on high-speed trains: Crosswind stability and discomforting car body vibrations inside tunnels*, Ph.D. Thesis, TRITA AVE 2006:81, KTH Rail Vehicles, 2006.

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

6.2 Licentiate theses

Lundberg S, *Freight customers' valuations of factors of importance in the transportation market.* Licentiate thesis, KTH, Stockholm, TRITA-TEC-LIC 06-001.

Berggren E, *Dynamic track stiffness measurement – A new tool for condition monitoring of track substructure*, Licentiate Thesis, TRITA AVE 2005:14, KTH Railway Technology, 2005.

Brabie D, *On the influence of rail vehicle parameters on the derailment process and its consequences*, Licentiate Thesis, TRITA AVE 2005:17, KTH Railway Technology, 2005.

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

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

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.

6.3 M.Sc. theses

Johannesson O, *Hantering av störd tågtrafik hos SJ AB*. Examensarbete Transportation and Logistics 05-102, 2005.

Nashed A, *Analys av åtgärder för ökad punktlighet vid avgång söderut från Stockholms Central*. Examensarbete Transportation and Logistics 05-078, 2005.

Gunnervall M, *Kapacitetsanalys av alternativa förbigångsspår på Götalandsbanan mellan Göteborg och Borås*. Examensarbete Transportation and Logistics 05-024, 2005.

Orvnäs A, *Simulation of rail wear on the Swedish light rail line Tvärbanan*, M.Sc. Thesis, TRITA AVE 2005:12, KTH Railway Technology, 2005.

Claesson S, *Modelling of track flexibility for rail vehicle dynamics simulation*, M.Sc. Thesis, TRITA AVE 2005:26, KTH Railway Technology, 2005.

Parczewski E, *Modelling and simulation of train coupling dynamics,* M.Sc. Thesis, TRITA AVE 2005:47, KTH Railway Technology, 2005.

Skoglund M, *Dual-mode locomotives – a systems study*, M.Sc. Thesis, TRITA AVE 2005:49, KTH Railway Technology, 2005.

Öberg J, *Track deterioration of ballasted tracks*, M.Sc. Thesis, TRITA AVE 2006:88, KTH Rail Vehicles, 2006.

Brodén E, *Wheel wear and reduced reprofiling for Swedish Rc4 loco*, M.Sc. Thesis, TRITA AVE 2006:106, KTH Rail Vehicles, 2006.

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

Björklund L, *Dynamic Analysis of a Railway Bridge subjected to High Speed Trains*, TRITA-BKN. Master thesis 218, Structural Design and Bridges, Royal Institute of Technology, Stockholm, 2005.

Núria Barnils Vila, *Field testing and Theoretical analysis of the dynamic response of the Banafjäl railway bridge*, TRITA-BKN. Master thesis 225, Structural Design and Bridges, Royal Institute of Technology, Stockholm, 2005.

Lundin J, *Losses in Induction Motor Drive Systems for Rail Vehicles*, EX-ETS/EME 05-16, KTH 2005

6.4 Text books and reports

Fröidh O, Nelldal, B-L, *Tåget till framtiden – järnvägen 200 år 2056*. KTH TRITA-TEC-RR 06-004, 2006.

Fröidh O, *Nytt liv med järnvägen. In Järnvägen 150 år*, 167-187. Banverket/Informationsförlaget. Also published as a reprint, 2006, KTH TRITA-TEC-RR 06-002, 2005.

Nelldal B-L, Troche G, Ahlstedt L, *Godstrafikutredning för Inlandsbanan*. KTH TRITA-INFRA 05-006, 2005.

Nelldal B-L, *Nya fordon 1981-2006*. Särtryck ur Järnvägen 150 år TRITA-TEC-RR 06-003, 2006.

Andersson E, Berg M, Stichel S,: *Rail Vehicle Dynamics*, Text book, KTH Railway Technology, Stockholm 2005.

Iwnicki S (ed.), *A Handbook of Railway Vehicle Dynamics*, CRC Press, London, 2006. ISBN:0849333210. Evert Andersson, Mats Berg and Ulf Olofsson contributed to three different chapters.

7. Other activities

7.1 EURNEX

EUropean Rail research Network of EXcellence (EURNEX)

Researchers: Stefan Östlund (KTH part), Mats Berg

Source of funding: European Commission

This EU project for 2004-2007 aims at creating a Network of Excellence for railway research and education. About 65 universities and institutes all over Europe participate in this project. The KTH work first mainly focused on integrating education and training efforts in railway engineering among different European countries. Now formulation of, and application for, common research projects is the main part of the activities.

Berg M, *Railway activities at KTH Railway Group, in particular on vehicle–track interaction*; EURNEX Mini-symposium on Dynamic train-track interaction with applications, Chalmers, Göteborg, 19 May 2005.

Vinolas J, Berg M and Pereira M, *Courses and materials for Ph.D. and M.Sc.*, Report, Deliverable D62, 2006.

7.2 Seminars

On June 9th, 2005 a seminar on "Do we need new railway vehicles" was arranged. Speakers were Thomas Lange, consultant ÅF; Claes Ulveryd, Skånetrafiken; Thore Sekkenes, Bombardier Transportation; Dr Peter Bark, TFK, Professor Bo-Lennart Nelldal, KTH and Professor Stefan Östlund, KTH.

On May 19th, 2006, a seminar on "Efficient train systems for freight transport" was arranged. Speakers were Christer Beijbom, consultant; Professor Bo-Lennart Nelldal, KTH; Anders Clason, StoraEnso Transport; Dr Peter Bark, TFK and Björn Widell, K-Industrier.

7.3 Awards

Ulf Olofsson and Stefan Björklund were 2006 awarded with the ASME K.L Johnson award for co-authoring the best paper on the subject of contact mechanics.

Ulf Olofsson presented 2006 an IMech lecture about natural and applied lubrication of the wheel rail contact. (2006)

Eric Berggren et al. were given the "Best Paper Award on Safety" at the 8th International Heavy Haul Conference in Rio de Janeiro, Brasil, 14-16 June, 2005.

Johan Öberg was given the prize for the "Best MSc Thesis 2006" by the Swedish Society of Railway Industries (SWEDTRAIN).

7.4 Scientific assignments

Ulf Olofsson was faculty opponent of Patric Waaras Ph.D. thesis *Lubricants influence on wear in sharp rail curves* at Luleå Technical University 2006.

Bo-Lennart Nelldal was opponent of Arvid Kauppis licentiate thesis *A Human-Computer Interaction Approach to Train Traffic Control* at Uppsala University 2006.

Sebastian Stichel was opponent of Andreas Lundqvist's licentiate thesis *Dynamic train/track interaction – Hanging sleepers, track stiffness variations and track settlement* at Linköping University, April 2005.

Mats Berg was opponent of Håkan Lane's licentiate thesis *Rail vehicle – Track structure – Subgrade Computational analysis – Integrated finite element techniques* at Chalmers University of Technology, Gothenburg, June 2005.

Evert Andersson was expert for the appointment of Jens Nielsen as professor at Chalmers University of Technology, Gothenburg, May 2006.

Evert Andersson was member of the evaluation committee for Tore Vernersson's Ph.D. thesis *Tread braking of railway wheels – Noise-related tread roughness and dimensioning wheel temperatures* at Chalmers University of Technology, Gothenburg, June 2006.

Mats Berg was member of the evaluation committee for Per-Anders Wernberg's Ph.D. thesis *Structure-acoustic analysis – Methods, implementations and applications* at Lund University, June 2006.

Mats Berg was faculty opponent of Mark Hoffmann's Ph.D. thesis *Dynamics of European two-axle freight wagons* at Danmarks Tekniska Universitet (DTU), November 2006.

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