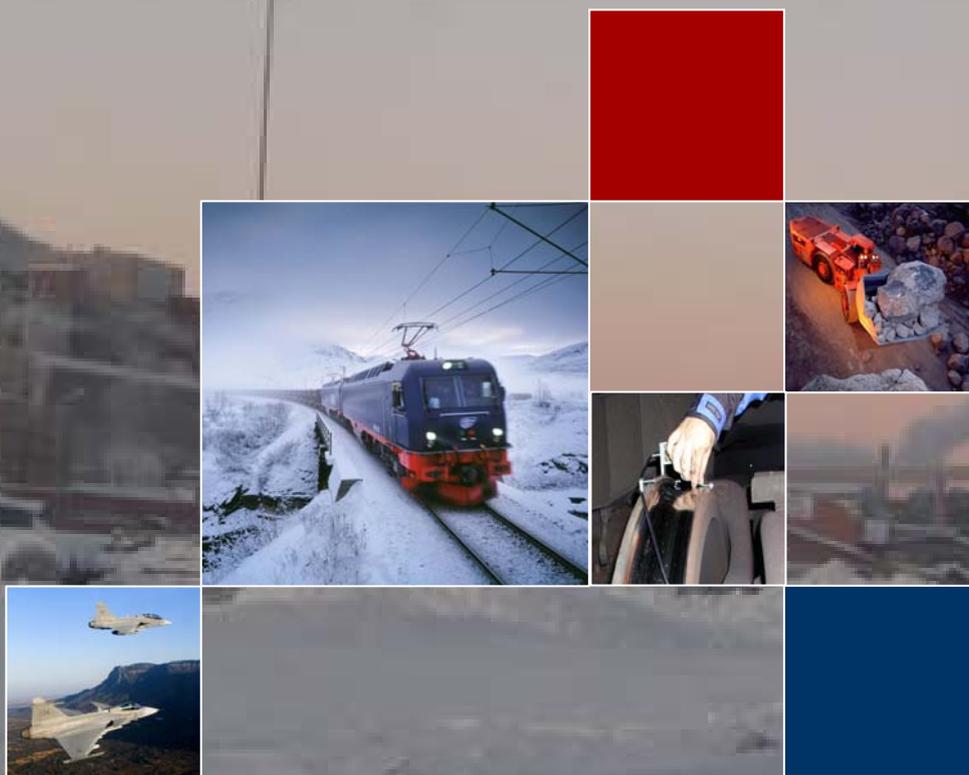


ANNUAL REPORT

2008

Teaching and Research Activities



**Division of Operation and
Maintenance Engineering**

LULEÅ
UNIVERSITY
OF TECHNOLOGY

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“...see this as an opportunity to introduce new technologies for trimming out inefficient activities.”

Recession knocking at the doors, industries and business organisations are busy using the downturn in the economy to streamline their business processes to enhance their overall performance. We in academia also see this as an opportunity to introduce new and proven technologies for trimming out inefficient activities, practices and processes. To support industries in achieving excellence in performance and bringing costs under control, we are open to realign and reorganise our R&D process to inspire the confidence of our sponsors by delivering timely solutions to meet their requirements. Simply speaking, we have to prioritise need driven research required by business organisations and industrial sector without losing focus on basic and fundamental research. It is important that our research solutions are based on sound scientific principles.

The Division of Operation and Maintenance Engineering has been working consistently in close collaboration with Swedish and European industries and has been successful in securing research projects from the Swedish Foundation for Strategic Research (SSF) and VINNOVA (the Swedish Governmental Agency for Innovation Systems), besides securing long-term strategic research grants from Banverket (the Swedish National Rail Administration). Moreover, over the years we have established partnerships with many leading industrial companies, such as Saab Aerotech, Airbus, ALSTOM Transport, LKAB, Boliden, and Sandvik Mining and Construction, to name a few.

The Division has also produced *six* PhDs during 2008, which can be judged to be a remarkable achievement for the research group.

Our achievements since the establishment of the Division in 2002 make us confident that we are on the right path. I am grateful to my colleagues, the University management, our sponsors and other stakeholders for their constant support and encouragement.

It gives me immense pleasure to present the annual report of the Division and to provide its readers with an overview of our activities during the past twelve months.

Uday Kumar

Dr. Uday Kumar
Professor and Head

30 March 2009

The Division of Operation & Maintenance Engineering



Left to right:

Standing - Jakob Nordström, Andy Wijaya, Rupesh Kumar, Rajiv Dandotiya, Ambika Patra, Iman Arastehkhoy, Sten-Erik Björling, Alireza Ahmadi, Håkan Schunnesson, Mikael Palo

Sitting - Ramin Karim, Peter Söderholm, Jan Lundberg, Uday Kumar, Cecilia Glover, Zeaba Madani-Mousavi, Aditya Parida

Not in the photo:

Anna Gustafson, Jan Block, Olov Candell, Dan Larsson, Arne Nissen, Ulf Olsson, Ulf Sandberg, Olof Wååk, Behzad Ghodrati, Yuan Fuqing

The Division of Operation and Maintenance Engineering was established in the year 2002. Since then, the Division has mapped a long distance to establish itself as a pioneer research group in the field of operation and maintenance engineering. The Division works in close co-operation with industries and other Research Groups active in field of operation and maintenance engineering worldwide. In these 7 years of existence, the Division has not only been able to produce a number of peer reviewed international journals publications, research theses but has also been providing solutions to industry's problem related to operation and maintenance engineering. With the increasing awareness that maintenance not only ensures safe and sustainable performance, but also creates added value in the business process, the industries have started to consider maintenance as an integral part of the business process, while applying a holistic view of the asset engineering and management.

The subject area of Operation and Maintenance Engineering is multidisciplinary in nature, transcending the boundaries separating many disciplines of science and arts. Keeping this in mind, the activities of the Division are aligned to find synergies with other engineering disciplines and build networks with many active research groups, locally and all over the world.

The Division of Operation and Maintenance Engineering during the 7 years of its existence has grown in size and at the closing of 2008, have 12 faculty staffs, 3 visiting professors and 14 PhD students including 4 industrial/external PhD students.

Faculty Members

- **Uday Kumar, Professor and Head**
- Jan Lundberg, Professor
- Ulf Olsson, Adjunct Professor
- Ulf Sandberg, Adjunct Professor
- Olof Wååk, Adjunct Professor
- Aditya Parida, Assistant Professor
- Behzad Ghodrati, Assistant Professor
- Håkan Schunnesson, Assistant professor
- Peter Söderholm, Assistant Professor
- Ramin Karim, Assistant Professor
- Rupesh Kumar, Research Associate
- Jakob Nordström, Research Engineer

Visiting Faculty

- Professor D N P Murthy, Queensland University, Australia
- Professor A K S Jardine, University of Toronto, Canada
- Professor Jay Lee, University of Cincinnati, USA

Administration

- Cecilia Glover, Project Administrator
- Sven Lindahl, Project Administrator

PhD Students

- Ambika Patra
- Rajiv Dandotiya
- Anna Gustafson
- Zeaba Madani-Mousavi
- Iman Arastehkhoy
- Alireza Ahmadi
- Yuan Fuqing
- Arne Nissen
- Mikael Palo
- Andi Rahadiyan Wijaya

Industrial PhD students

- Olov Candell (Saab Aerotech)
- Jan Block (Saab Aerotech)
- Sten-Erik Björling (Enviro Data)
- Dan Larsson (Damill AB)

Education

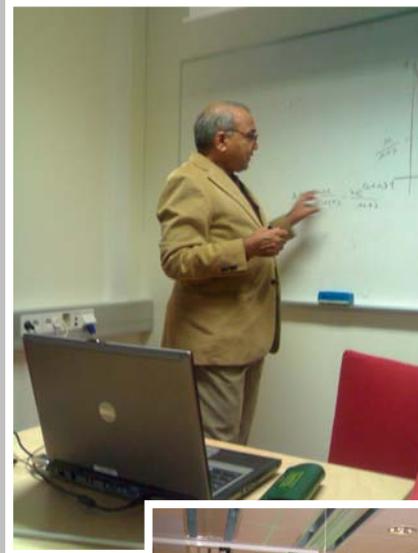
The Operation and Maintenance group is involved in teaching of many undergraduate, graduate and postgraduate programmes. The Division has also an agreement for a joint Master Programme in Maintenance Management and Engineering with Sharif University of Technology, Tehran. Apart from this, every year many seminars and Continuing Education Programmes are also organised and taught

Undergraduate & Graduate Programme

Undergraduate education is one of the core activities of the Luleå University of Technology (LTU). The Division is involved in teaching a number of LTU's Engineering programmes, including courses in Operation and Maintenance, which are provided for the Civil Engineering MSc programmes, Sustainable Energy Engineering, Mining and Geotechnical Engineering. Basic courses are also provided in the BSc programme in Aviation Engineering. The Division conducts courses in Mining Equipment Engineering and Mine Automation for the Mining Engineering students at the University. For the last few years, the Division has also been responsible for courses in mine automation and maintenance in the European Mining Course taught at Helsinki University of Technology, Finland.

The following undergraduate courses were conducted by the Division of Operation and Maintenance Engineering:

- Applied Operations Research
- Mine Automation
- Operation and Maintenance - Hydropower
- Reliability and Maintenance
- Aviation Reliability and Maintenance Technology
- Production Equipment Management
- Operation and Maintenance Engineering



Prof. K B. Misra teaching Reliability Theory.



Postgraduate Programme

Postgraduate studies at Luleå University of Technology include two higher degrees: Licentiate in Engineering and PhD in Engineering. Both degrees are awarded by Luleå University of Technology in recognition of the candidates' theoretical and applied knowledge and command of a wide range of related subjects in a given academic discipline. In general, it takes 4 to 5 years to obtain a PhD degree, and approximately half that time to obtain a Licentiate degree.

The following courses at postgraduate level are given by the Division of Operation and Maintenance Engineering:

- Asset Engineering and Management
- Life Cycle Costing (LCC): Theory & Application
- Applied Reliability Engineering
- Risk & Vulnerability Analysis
- Advanced Maintenance: Theory & Application
- Performance Measurement and Management
- Product Support & Industrial Services
- Research Methodology in Engineering
- Stochastic Models for Reliability Analysis and Maintenance Optimization

PhD Degrees Awardees – 2008

1. Birre Nyström

Thesis Title: Aspects of improving punctuality: from data to decision in railway maintenance.

Main examiner: Professor Rommert Dekker, Erasmus University, The Netherlands.

At present: Norway State Railways, (NSB) Norway



The goal of the research thesis is to explore and describe information and requirements related to railway punctuality in order to support systematic improvements. The focus was on delay causes related to infrastructure maintenance. To fulfil the stated purpose, punctuality requirements, availability concepts, failure and delay data, as well as maintenance decisions, had been studied using theoretical and empirical model. (see: <http://epubl.ltu.se/1402-1544/2008/11/index.html>)

2. Saurabh Kumar

Thesis Title: Reliability analysis and cost modelling of degrading systems

Main examiner: Professor Kurt Petersson, Lund University, Sweden

At present: Senior Reliability Consultant at SKF, Stavanger, Norway.



The research work demonstrates application of reliability engineering to improve system performance based on design changes. This has been illustrated with an example from a manufacturing industry. The objective is achieved using cost-benefit analysis in combination with failure data and root cause analysis. The analysis of failure data with the different cost elements involved in the operation and maintenance of the complex systems is presented as a basis for choosing between alternative designs. The thesis discusses the application of reliability analysis and cost modeling techniques to support the decision-making process in operation and maintenance activities and demonstrates its usefulness in real life. (see <http://epubl.ltu.se/1402-1544/2008/15/index.html>)

3. Thomas Åhrén

Thesis Title: Maintenance performance indicators (MPIs) for railway infrastructure: identification and analysis for improvement

Main examiner: Professor Basim Al-Najjar, Växjö University, Sweden

At present: Working as research Engineer at SINTEF, Trondheim, Norway



Purpose of this research work is to identify and study the existing operation and maintenance performance indicators related to railway infrastructure, their application in short term and long-term perspective to analyse their usefulness for operation and maintenance planning of the railway infrastructure. In the thesis relevant MPIs for effective management of operation and maintenance of the railway infrastructure are identified and analyzed. Further, models like LinkEM and ORIE are suggested for the railway infrastructure managers to facilitate in the decision-making. (see: <http://epubl.ltu.se/1402-1544/2008/19/index.html>)

4. Rikard Granström

Thesis Title: Management of condition information from railway punctuality perspectives

Main examiner: Professor D N P Murthy, Queensland University, Australia

At present: Consultant Engineer at Vectura, Sweden.



The purpose of this research is to explore and describe how information about the condition of technical systems can support stakeholders within the Swedish railway in improving punctuality by means of more effective and efficient maintenance. The thesis outlines a possible scenario in which condition information could support railway stakeholders in improving the punctuality of the railway system by means of more effective and efficient maintenance. (see: <http://epubl.ltu.se/1402-1544/2008/36/index.html>)

5. **Ramin Karim**

Thesis Title: A service-oriented approach to e-Maintenance of complex technical systems



Main examiner: Prof. Benoit Iung, University Henri Poincarè, Nancy, France

At present: Working as an Assistant Professor, Div. of Operation & Maintenance Engineering, Luleå University of Technology, Luleå, Sweden

The objective of the thesis is to explore and describe how an e-Maintenance solution can be developed to provide information services that support the maintenance of complex technical systems. The results of this research are: I) an exploration and definition of e-Maintenance; II) a description of e-Maintenance as support to maintenance of complex technical systems; III) an e-Maintenance Management Framework (e-MMF) for establishment of an e-Maintenance platform; and IV) a methodology with a supporting toolbox that facilitates the identification of maintenance support information. (see: <http://epubl.ltu.se/1402-1544/2008/58/index.html>)

6. **Stefan Niska**

Thesis Title: Measurements and analysis of electromagnetic interferences in the Swedish railway systems



Main examiner: Prof. A. K. Verma, Indian Institute of Technology, Bombay, India

At present: Working as an Engineer at Banverket, Luleå, Sweden.

The purpose of the research study is to study and explain the cause of EMC problems in electrical and electronic systems in the railway infrastructure, and also discuss how to use the knowledge of EMC problems in design and construction in future railway projects. The knowledge generated will be of assistance in designing new signalling and detector equipment which will have a higher level of reliability, leading to a smaller number of failures and EMC problems. The study has made a contribution towards an understanding of the EMC and EMI characteristics of the signalling and detector infrastructure of the railway system. These characteristics often lead to failures resulting in train delays. (see: <http://epubl.ltu.se/1402-1544/2008/76/index.html>)

“On the eve of convocation ceremony - 2008”



Prof. Kumar (3rd from left) with his newly graduated PhD students

Research Activities

Research in maintenance involves various disciplines of engineering. The scope of R&D of Division covers different areas of engineering sciences and management leading to integrated maintenance engineering solutions for industrial problems. Effective R&D efforts, always lead to energy saving and attaining the sustainability goals.

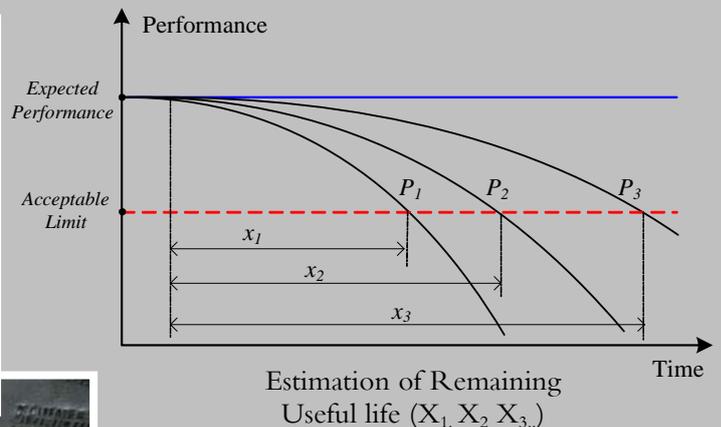
The Division has built up competence in the field of operation and maintenance engineering and management with special focus on reliability, availability and maintainability (RAM), asset engineering and asset management. The Division's capability covers the asset engineering, reliability and maintainability modelling, risk management, condition monitoring, LCC and LCP, service and product support, e-maintenance, performance management, etc. We are actively working towards the implementation of new and emerging technologies in operation and maintenance engineering of complex Industrial System.

The core research areas identified for strategic focus are:

- RAM
- LCC/LCP
- Product Support and service engineering
- Remaining Useful Life Estimation
- Maintenance decision modeling
- Condition Monitoring
- e-Maintenance.

We are also developing scientific basis to assess the contribution of maintenance towards energy saving and sustainability.

Our Division operates in active collaboration with industries and other research groups nationally and internationally undertaking applied research projects on an ongoing basis. Our industrial client list includes companies from the railway, aerospace, mining, energy, process and service industries. Our faculty members are known to blend theory with practical solutions with a knowledge base built up over years of experience.



International Collaboration and Networking

To strengthen our position, it is imperative that we network with all related and active research groups, nationally and internationally. Keeping this in view, networking and close collaboration has been the key result area for our division. We have succeeded in achieving formal and informal networking and collaboration with research groups in the following industries and universities outside Sweden.

- Airbus, France
- ALSTOM Transport, France
- Benaras Hindu University, India
- Central Queensland University at Gladstone, Australia
- Helsinki University of Technology, Finland
- Indian Institute of Technology Bombay, India
- Indian Institute of Technology, Kharagpur, India
- Kemi Tornio University of Applied Science, Finland
- Queensland University of Technology, Brisbane, Australia
- Sharif University of Technology, Iran
- Tehran University, Iran
- Tromsø University, Norway
- University of Cincinnati, USA
- University of Queensland, Australia
- University of Stavanger, Norway
- University of Toronto, Canada
- VTT, Helsinki, Finland

Our division is one of the initiating members of the European Research Network on Strategic Engineering Asset Management (EURENSEAM), and has participated in meetings and seminars during 2007. We are also a member of the European Network of Excellence (NoE), initially sponsored by the EU FP 6 Framework Programme (EURNEX).



Prof. Uday Kumar, delivered opening key note speech at Pan Arab maintenance congress at Riyadh.

Collaborative Research Centres

The research group at the division is closely associated with two collaborative research centres; namely, the Centre for Maintenance and Industrial Services (C-MIS) and the Luleå Railway Research Centre (JVTC).

Centre for Maintenance and Industrial Services (C-MIS)

C-MIS is a collaborative platform initiated by Luleå University of Technology in close cooperation with industrial partners.

The vision of C-MIS is to become a national platform of cooperation for research and development and a centre of excellence in the field of maintenance and industrial services.

The business goal of C-MIS is to conduct coordinated competence development, applied research and development work focusing on new technology, organization and financial issues to increase the efficiency and effectiveness of plant, installations, industrial services and products.

A number of Swedish industries and organizations have already joined C-MIS under different levels of membership. The following companies and organizations were members of C-MIS at the close of 2008.

- | | |
|-----------------------------|---------------------------|
| 1. Boliden Mineral | 2. Vattenfall tjänster AB |
| 3. LKAB | 4. Saab Aerotech |
| 5. Bilerud AB | 6. Hägglunds Drives |
| 7. SKF Condition Monitoring | 8. Dynamate |
| 9. Smurfit Kappa | 10. Skelleftekraft |
| 11. Underhållsbyrån in Norr | 12. FMLOG |
| 13. Vattenfall Vattenkraft | |

During 2008, C-MIS undertook various activities to promote dialogue and interaction in an effort to understand the engineering support requirements of industry. C-MIS organized 4 seminars and workshops for this purpose. Leading professors and experts from France, Finland India and Swedish industries delivered interactive lectures for the benefit of our industrial partners. Open-dialogue on various industrial issues and challenges was undertaken in the workshops, followed by the seminars, which provided an opportunity to understand the industrial perspective for initiating joint research projects.

Seminars were organised for the members of C-MIS and academia during the year. Some of the speakers were invited from abroad: Prof. Rommert Dekker, Erasmus University, The Netherlands; Dr, Erkki Junatanen, VTT; Prof. Benoit Iung University Henri Poincarè, Nancy, France; SKF; Prof. K B. Misra, IIT Kharagpur; Mr. Marcel Van Velthoven & Prof Piet M Lugt, SKF, The Netherland; Prof Ajit Verma, IIT-Bomaby, India; Prof Raj Rao, COMADEM, UK.



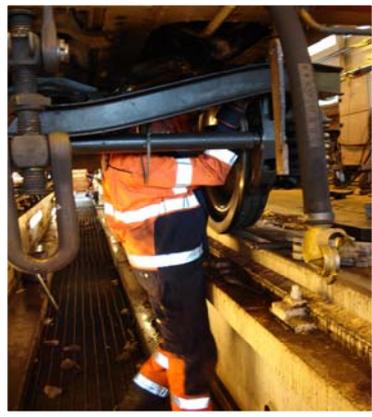
Prof. Benoit Iung (3rd from left) discussing e-Maintenance issues with industries representatives



Prof. Raj Rao giving seminar at C-MIS

Luleå Railway Research Centre (Järnvägstekniskt Centrum: JVTC)

JVTC, a cooperative research centre at Luleå University of Technology (LTU) in Luleå, Sweden, was established in close cooperation with the Swedish National Rail Administration (Banverket), the LKAB ore transport company (MTAB), Duroc Rail and Luleå University of Technology, among others.



The main focus of JVTC is to provide solutions to maintenance problems to facilitate the smooth operation of the railway system. The centre has been able to undertake a number of challenging applied research projects and provide successful solutions to the satisfaction of our railway partners. The centre is currently headed by Professor Uday Kumar and funded by industries. A remote condition monitoring station, located about 40 km north of Luleå, was established by JVTC during the year 2007 for collecting data concerning different types of forces exerted on railway track by rolling stock in real time, which can be monitored from anywhere in the world via the Internet.

JVTC – 10 Year Celebration

The JVTC celebrated its 10th anniversary by organising two days seminar on “Technology and Trends in Railway Engineering” at Luleå University of Technology, on December 4-5, 2008. The members of the Railway centre, railway executives, researchers and sponsors attended the seminar and made presentations highlighting the achievements made by the railway sector. The presentations and discussions also covered the present issues being faced by the sector, challenges and possible solutions for the railway sector. Several industries participated in the workshops. The inaugural speech was given by the Honourable County Governor, His Highness Per-Ola Ericsson.



Prof. Kumar in dialogue with County Governor His Highness Per-Ola Ericsson during the seminar.



Some of the participants at 10th anniversary of Luleå Railway Research Centre

Research Projects

On-going Projects

Development and implementation of RAMS and LCC model for railway track system

Sponsor: JVTC and Banverket
Researcher: Ambika Prasad Patra, Ulla Juntti, Uday Kumar
Objective: Development and application of RAMS and LCC model to enhance the effectiveness maintenance of railway track system.
Duration: 2005 – 2009

e-Maintenance 24/7

Sponsor: VINNOVA, Swedish National Aeronautics Research Programme (NFFP) and Saab Aerotech
Researcher: Olov Candell, Ramin Karim and Peter Söderholm
Objective: To explore and describe applications of e-Maintenance concepts in order to increase the technical availability and decrease operational and support costs for customer and product support of geographically distributed aircraft systems.
Duration: 2006 – 2009

Efficient utilization of customer and product support data

Sponsor: VINNOVA, Swedish National Aeronautics Research Programme (NFFP) and Saab Aerotech
Researcher: Jan Block and Peter Söderholm
Objective: To explore and describe statistical approaches to extract information efficiently from product support related data, recorded during operation and support of aircraft systems.
Duration: 2006 – 2009

From data to decision support

Sponsor: LKAB/MTAB
Researcher: Dan Larsson, Ulla Juntti, Håkan Schunnesson and Uday Kumar
Objective: Develop methodology to convert data to relevant information for decision making processes.
Duration: 2008 – 2009

LCC analysis of Switches and Collectors (S&C) in rail track

Sponsor: Banverket
Researcher: Arne Nissen
Objective: To develop a LCC-model for a S&C in order to make decision for changes in maintenance strategy and/or when to make replacement of old S&C.
Duration: 2006 – 2009

An assessment of operational consequences of failures to support aircraft scheduled maintenance program development

Sponsor: LTU and AIRBUS
Researcher: Alireza Ahmadi and Uday Kumar
Ind. adviser: Christian Delmas/AIRBUS.
Objective: To develop a methodology for identifying different operational consequences and associated costs caused by aircraft system failure, in order to facilitate and enhance the capability of taking correct and efficient decisions when analyzing maintenance tasks.
Duration: 2007 – 2009

Establishment and management of research station

Sponsor: LKAB and Banverket
Researcher: Ulla Juntti, Dan Larsson and Uday Kumar
Objective: The goal is to establish measurement system for measuring the forces generated at track and transfer of these measurements in predefined formats to stakeholders by the use of internet in real time on demand.
Duration: 2008 – 2011

Railway vehicle classification study

Sponsor: Banverket and JVTC
Researcher: Dan Larsson, Uday Kumar and Ulla Juntti
Objectives: In order to plan the track maintenance and also in the future to stipulate track access charges it is necessary to classify the vehicles based on its type, axle load and speed, by their running characteristics, by analysis of the monitored data.
Duration: 2006-2009

Maintenance threshold limits

Sponsor: LKAB, Banverket and Jernbaneverket/Norge
Researcher: Iman Arastehkhoy, Håkan Schunnesson, Ulla Juntti and Arne Nissen
Objectives: The main goal of this project is to define issues and challenges associated with correct estimation of threshold limits for rail and wheels.
Duration: 2007-2011

Condition monitoring diagnostics & prognostics

Sponsor: VINNOVA, LKAB & Boliden
Researcher: Rajiv Dandotiya, Jakob Nordström, Jan Lundberg and Aditya Parida
Objective: The project aims to develop optimum maintenance strategies for mining mills liners and develop methods deal with cracks in mill liners.
Duration: 2008 – 2012

InMaint: Integrated maintenance for improved products and production

Sponsor: Pro Viking, SSF, (Boliden, Sandvik, Contector Volvo body and Volvo Aero)
Researcher: Uday Kumar, Håkan Schunnesson and Jan Lundberg
Objective: The aim to increase productivity, reduce production costs and to generate valuable input for improved engineering design of products and production.
Duration: 2008 – 2012

Innovative e-Maintenance services for industries

Sponsor: Interreg/EU
Researcher: Ramin Karim, Aditya Parida, Asalak Siimes Alireza Ahmadi and Peter Söderholm
Objective: To investigate the application of IT in decision making process in maintenance and examine methodology, tools and technologies useful for developing e-Maintenance solutions with special reference to process industries.
Duration: 2009 – 2011

e-Maintenance for railway system

Sponsor: Banverket
Researcher: Ramin Karim and Uday Kumar
Objective: To investigate the application of IT in decision making process in maintenance and examine methodology, tools and technologies useful for developing e-Maintenance solutions.
Duration: 2009-2011

SVC project

Sponsor: SVC, Vattenfall Vattenkraft, and Vattenfall Services
Researcher: Ulf Sandberg
Objectives: Define strategic R&D areas for the improvement of operation and maintenance of Hydro Power plants in close cooperation with all the stake holders of SVC (Swedish Hydropower Center).
Duration: 2008-2009

Maintenance survey of Swedish industries

Sponsor: Underhållsföretagen AB
Researcher: Aditya Parida, Håkan Schunnesson and Uday Kumar
Objective: To undertake maintenance survey of the Swedish industry in order to know their performance indicators like availability, quality of production, and maintenance costs and overall equipment effectiveness etc.
Duration: 2008 – 2009

Increased track capacity through improved maintenance

Sponsor: JVTC and LTU
Researcher: Yuan Fuqing, Rajiv Dandotiya and Uday Kumar
Objective: Develop models and plan for track possession so as to enhance the track capacity on the existing track.
Duration: 2008 – 2009

Design for maintainability in the Arctic climate

Sponsor: EniNorge and Norwegian Research Council
Researcher: Rupesh Kumar and Javad Barabady
Objective: The aim of the project is to improve the operation and maintenance effectiveness of oil and gas installation with special reference to cold and harsh environment by improving maintainability characteristics in considering human factors
Duration: 2008 – 2009

Road vehicle inspection procedure

Sponsor: VINNOVA
Researcher: Rupesh Kumar
Objective: The goal of the project is to facilitate and establish a technology transfer network between Govt. of India and Bilprovingen (Swedish Vehicle inspection System), for the implementation of inspection procedure in India.
Duration: 2008 – 2009

Condition monitoring of railway vehicles

Sponsor: LKAB and Banverket
Researcher: Mikael Palo, Håkan Schunnesson and Uday Kumar
Objective: The aim of the study is to develop tools and methods for effective condition monitoring of railway vehicles.
Duration: 2008 – 2009

Completed Projects

Vattenfall process for condition monitoring

Sponsor:	Vattenfall AB
Researcher:	Arne Nissen, Alireza Ahmadi and Håkan Schunnesson
Objectives:	Describe the current way Vattenfall Vattenkraft is working with condition monitoring. Give a theoretical framework of what condition based maintenance could be in Vattenfalls context.
Duration:	2006–2007

Maintenance strategy for railway infrastructure

Sponsor:	Banverket
Researcher:	Ulla Espling and Aditya Parida
Objective:	To study Banverkets maintenance process and suggest a framework for the development of optimal operation and maintenance strategy for Swedish rail road administration.
Duration:	2002 – 2007

Onboard diagnostics and prognostics

Sponsor:	VINNOVA, Swedish National Aeronautics Research Programme (NFFP) and Saab Aerosystems
Researcher:	Peter Söderholm, Per-Anders Akersten and Uday Kumar
Objective:	To examine important stakeholders and their requirements as regards critical system health information. To study and analyze hazards related to health information retrieved through Built-in Test systems and combined with information from external test systems.
Duration:	2002 – 2006

Condition based maintenance strategy for railway systems

Sponsor:	Banverket and LKAB
Researcher:	Robert Lagnebäck, P-O Larsson-Kraik and Uday Kumar
Objective:	To increase technical and economic benefits of the railway system using condition monitoring and condition based maintenance with focus on the rolling stock.
Duration:	2004 – 2007

Implementation of production assurance programmes

Sponsor:	The Ministry of Science, Research and Technology of Iran, LTU and Norwegian Research Council, Norway
Researchers:	Javad Barabady, Uday Kumar, Tore Markeset
Objective:	To study and evaluate the implementation of production availability/assurance programmes for production plants to facilitate correct decision making.
Duration:	2005 – 2007

Improvement of system availability using reliability and maintainability analysis

Sponsor:	The ministry of Science, Research and Technology of Iran
Researcher:	Javad Barabady and Behzad Ghodrati
Objective:	To develop a model for improvement of system availability using the concept of importance measure.
Duration:	2003 – 2005

Issues and challenges related to rail maintenance strategy

Sponsor:	CRC rail (Australia) and JVTC
Researcher:	Saurabh Kumar and Uday Kumar, Gopi Chattopadhyay (QUT, Australia)
Objective:	To provide cost modelling to reduce the rail maintenance cost. The project also aims to provide solutions to the current challenges faced by rail players in the rail grinding and lubrication areas.
Duration:	2004 – 2006

Improved train punctuality through improvement in engineering systems

Sponsor:	Banverket and EU structural funds
Researcher:	Rikard Granström, Uday Kumar
Objective:	To improve train punctuality by use of effective and efficient maintenance technology.
Duration:	2003 – 2008

Modelling and analysis of track degradation mechanism

Sponsor:	Banverket and Damill AB
Researcher:	Dan Larsson, Johan Gunnarsson
Objective:	To develop and test models for rail track wear under different load conditions. To develop models and methods to facilitate introduction of differentiated freight charges depending on the quality of railcars and vehicles.
Duration:	2002 – 2006

Reliability and operating environment based spare parts planning

Sponsor:	JVTC, LTU–Arena MTN
Researcher:	Behzad Ghodrati, Uday Kumar and Per Anders Akersten
Objective:	To develop an approach and decision model for the integration of the product reliability characteristics while considering the product operating environment in the optimal estimation of product support (required spare parts).
Duration:	2002 – 2005

Development of maintenance performance indicators for a pelletization plant at LKAB

Sponsor: LKAB and LTU
Researcher: Aditya Parida and Arne Nissen
Objective: To study the maintenance stops in the balling area of the KK3 plant of LKAB to develop maintenance indicators linked to improvement in production rate (speed) and product yield (quality).
Duration: 2005 – 2006

Maintenance related risks in Swedish railway system

Sponsor: Banverket, JVTC and EU structured fund
Researcher: Mattias Holmgren, Peter Söderholm, Per Anders Akersten and Uday Kumar
Objective: To control the contracted maintenance works better and thereby ensure safety for passengers and personnel at the Swedish National Rail Administration (Banverket).
Duration: 2004 – 2006

Identification of maintenance performance indicators (MPI) for Vattenfall Service AB

Sponsor: Vattenfall AB
Researcher: Aditya Parida and Håkan Schunnesson
Objective: To study and analyze the maintenance process and function in order to identify possible maintenance performance indicators (MPI) appropriate to the operations/services of Vattenfall.
Duration: 2005

Improved punctuality through effective maintenance management

Sponsor: Banverket and EU structural funds
Researcher: Birre Nyström, Per-Anders Akersten and Uday Kumar
Objective: To improve train punctuality by studying the root causes for delay related to maintenance organizations and operational environment, and suggest measures to enhance the effectiveness of maintenance system in Swedish railway sector.
Duration: 2002 – 2008

Optimum maintenance decision for LRU of the aircraft fleet

Sponsor: SAAB
Researcher: Rajiv Dandotiya and Yuan Fuqing
Objective: To develop a decision support tool for the optimum maintenance of LRU for the aircraft fleet
Duration: 2008

Maintenance performance indicators (MPIs) for Swedish Rail Administration

Sponsor: Banverket
Researcher: Thomas Åhren, Aditya Parida, P-O Larsson-Kråik and Uday Kumar
Objective: To study and analyze the effect of maintenance activities on punctuality, safety, environment and profitability. The expected result of this project will explain how different maintenance performance indicators can be used to facilitate correct decisions in the maintenance process.
Duration: 2002 – 2008

Development of inspection frequency optimization model for degrading offshore oil and gas platform infrastructure

Sponsor: Banverket and Akerkvaerner Offshore Partner (AKOP), Norway
Researcher: Saurabh Kumar, Rajiv Dandotiya, Uday Kumar,
Objective: To develop an optimization model which will assist in taking maintenance decisions, such as optimum inspection scheduling to minimize the total preventive maintenance cost of the system while assuring high reliability of its components and complying with HSE norms.
Duration: 2007 – 2008

Design for/out maintenance

Sponsor: Banverket
Researcher: Stefan Niska, Håkan Schunnesson and Uday Kumar
Objective: Investigate the electromagnetic compatibility problems resulting from the coexistence of multiple electrical signalling circuits along railroad tracks. To improve design in order to reduce maintenance that involves electromagnetic interference.
Duration: 2006 – 2008

An integrated approach to rail break prediction and rail degradation

Sponsor: JVTC, Banverket
Researcher: Saurabh Kumar, Uday Kumar, Behzad Ghodrati
Objective: To develop an effective maintenance procedure for rail maintenance based on rail failure prediction considering the factors influencing the rail degradation process
Duration: 2004 – 2008

Development of cost-effective maintenance policy for signalling systems

Sponsor: ALSTOM Transport, France
Researcher: Ambika Prasad Patra
Ind. adviser: Pierre Dersin, ALSTOM Transport
Objective: Optimisation of maintenance policy of signalling systems (Track circuit and Automatic Train Control system) to maximise cost-effectiveness.
Duration: 2008

Publications

Journal Papers

- Barabady, J., & Aven, T. (2008). A methodology for the implementation of production assurance in production plants. *In: Proceedings of the institution of Mechanical Engineers, Part O, Journal of Risk and Reliability*, 222, (3), 283-290.
- Barabady, J., & Kumar, U. (2008). Reliability analysis of mining equipment: a case study of a crushing plant at Jajram Bauxite Mine in Iran. *Reliability Engineering and System Safety*, 93, (4), 647-653.
- Chattopadhyay, G., & Kumar, S. (2008). Parameter Estimation for Rail Degradation Model. *Accepted for publication in International Journal of Performability Engineering*.
- Dandotiya, R., Fuqing, Y., & Kumar, U. (2008). Optimal Maintenance Decision for Line Repairable Units (LRUS) for an Aircraft System – A Conceptual Approach. *Journal of Operation Research, OPSEARCH*, Spl issue on Reliability and Maintenance, 45 (3), 291-302.
- Granström, R. (2008). A system and stakeholder approach for the identification of condition information: a case study for the Swedish Railway. *In: Proceedings of the institution of Mechanical Engineers, Part F, Journal of Rail and Rapid Transit*, 222, (4), 399-412.
- Holmgren, M. & Söderholm, P. (2008). A process approach to maintenance-related hazard identification. *International Journal of COMADEM*, 11, (1), 36-46.
- Kumar, S., Dandotiya, R., Kumar, R. & Kumar, U. (2008). Inspection frequency optimization model for degrading flowlines on an offshore platform. *International Journal of Reliability, Quality, and Safety Engineering*, 15, (2), 167-180.
- Kumar, S., Espling, U., & Kumar, U. (2008). A holistic procedure for rail maintenance in Sweden. *In: Proceedings of the Institution of Mechanical Engineers, Part F, Journal of Rail and Rapid Transit*, 222, (4), 331-344.
- Nyström, B. (2008). A methodology for measuring the quality of deviation reporting: applied to railway delay attribution. *International Journal of Quality and Reliability Management*, 25, (7), 656-673.

Outstanding Paper Award

Aditya Parida from Division was awarded with “Emerald Literati Network 2008 Awards of Excellence for “Outstanding paper” for the paper titled “Development of Multi-Criteria Hierarchical framework for Maintenance Performance Measurement (MPM)”.

Conference Papers

- Ahmadi, A., & Söderholm, P. (2008). Assessment of the operational consequences of aircraft failures: using event tree analysis. *IEEE Aerospace Conference. IEEE*, 1-14.
- Barabady, A., & Barabady, J. (2008). Slope stability analysis using probabilistic method: a case study. *Proceedings of the 5th International Conference and Exhibition on Mass Mining, Sweden*, 887-896.
- Barabady, J., & Kumar, U. (2008). Production assurance concept for a mine production system. *17th International Symposium on Mine Planning and Equipment Selection, China*, 379-387.
- Barabady, J., Markeset, T., & Kumar, U. (2008). Overall production assurance effectiveness. *Proceedings of the 3rd World Congress on Engineering Asset Management and Intelligent Maintenance Systems (WCEAM-IMS), China*, 202-206.

- Block, J., Söderholm, P., & Tyrberg, T. (2008). Changes in items' failure pattern during maintenance: an investigation of the perfect repair assumption. *The 54th Annual Reliability and Maintainability Symposium, USA*,
- Block, J., Söderholm, P., & Tyrberg, T. (2008). Evaluation of preventive maintenance task intervals using field data from a complete life cycle. *IEEE Aerospace Conference. IEEE*, 1-11.
- Candell, O., & Karim, R. (2008). eMaintenance: information driven maintenance and support. *Proceedings of the 18th International Conference on Flexible Automation and Intelligent Manufacturing, Sweden*, 365-372.
- Ghodrati, B. (2008). Enhancement of mining machineries availability through supportability. *Proceedings of the 5th International Conference and Exhibition on Mass Mining, Sweden*, 617-626.
- Gustafson, A., Parida, A., & Nissen, A. (2008). Optimizing productivity through performance measures for underground mining industry. *Proceedings of the 5th International Conference and Exhibition on Mass Mining, Sweden*, 371-378.
- Karim, R., Kajko-Mattsson, M., & Söderholm, P. (2008). Exploiting SOA within e-maintenance. *Proceedings of the 2nd International Workshop on System Development in SOA Environments, International Conference on Software Engineering, USA*, 75-80.
- Karim, R., Kajko-Mattsson, M., Söderholm, P., Candell, O., Tyrber, T., Öhlund, H., & Johansson, J. (2008). Positioning embedded software maintenance within industrial maintenance. *IEEE International Conference on Software Maintenance, USA*, 440-443.
- Lundberg, J., & Söderholm, P. (2008). Mechanical stability of grease and running temperature as indicators of railway roller bearing temperature. *ICOMS Conference Proceedings, Australia*. Pp...
- Parida, A. (2008). Maintenance performance assessment (MPA) framework for engineering asset. *International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore*.pp...
- Parida, A. (2008). Relevant health monitoring based maintenance for an effective strategic engineering asset management. *Proceedings of the 21st International Congress and Exhibition, COMADEM, Czech Republic*, 377-384.
- Patra, A., Söderholm, P., & Kumar, U. (2008). Uncertainty in life cycle cost of railway track. *The 54th Annual Reliability and Maintainability Symposium, Las Vegas, USA*, pp. xxx
- Rezvanianiani, S.M., Valibeigloo, M., Asghari, M., Barabady, J. (2008). Role of reliability analysis in optimization of preventive maintenance time interval: a case study. *Proceedings of the 3rd World Congress on Engineering Asset Management and Intelligent Maintenance Systems (WCEAM-IMS), China*, 1349-1356.

Chapters in Handbooks

- During the year 2008, members of the Group were invited to make contributions to forthcoming books related to their areas of interest:
- Kumar, U., & Parida, A. (2008). Maintenance performance measurement system. In Khairy, A.H.K., & Murthy, D.N.P. (Eds.), *Hand Book on Maintenance of Complex Systems* (pp. 459-478). Springer, UK.
- Kumar, U. (2008). System maintenance: trends in management and technology. In Mishra, K.B. (Ed.), *Handbook of Performability Engineering* (pp. 773-787). Springer, UK.

Espling, U., & Kumar, U. (2008). Benchmarking of the D.N.P. (Eds.), *Hand Book on Maintenance of Complex Systems*, (559–583) Springer, UK.

Parida, A. & Kumar, U. (2009). Maintenance Productivity and Performance Measurement, *Handbook of Maintenance Management & Engineering* Edited by Professor Saleh O. Duffuaa, In Press, UK.

Encyclopedia

Kumar, U., & Akersten, P-A, Availability and Maintainability. *Encyclopedia of Quantitative Risk Analysis and Assessment*. ed. / E. Melnik ; B. Everitt. p. 77-84 Chichester, UK: John Wiley & Sons, Ltd.

Guest Editors for Special Issues of Journals

- Special issue of International Journal of Performability -IJPE (Risk and Reliability Engineering), July 2008, Vol. 4(3). Guest editor: Uday Kumar
- Special issue of OPSEARCH on Reliability & Maintainability 2008, Vol. 47 (3) Guest editors: A. Srividya & Uday Kumar
- Special issue of International Journal of Quality in Maintenance -JQME (Condition Monitoring & ICT applications), 2009, Vol. 15, (2.) Guest editors: Uday Kumar & Aditya Parida
- Special issue of International Journal of Services Technology and Management IJSTM (On Industrial Services) UoS , Jan 2009, Vol 11 (1). Guest editors: Tore Markeset & Uday Kumar
- Special Issue of International Journal of COMADEM (Maintenance in Railway Sector) April 2009, Vol. 12 (2) . Guest editors: Uday Kumar, P-O Larsson-Kräik & Thomas Nordmark
- Special Issue of International Journal of Mining Reclamation and Environment (IJMRE (Reliability and Maintenance of Mine Production Systems) , June 2009, Vol.23, Guest editor: Uday Kumar

Keynote/invited speech

Kumar, U. (2008). Performance measurement: Measuring the Contribution of Maintenance towards business goals., 7th OMAINTEC, *The 7th Maintenance Congress, Riyadh, Saudi Arabia, October, 23-25, 2008.*

Maintenance Process in Railway, In Khairy, A.H.K., & Murthy, Kumar, U. (2008). *e-Maintenance 24-7 Concepts in Swedish National Railway Sector. ETA Group Seminar, Dubai*

Review of Journal papers

The faculty members of the Division are reviewers for the following International Journals and are member of the Editorial Advisory Board of some of the Journals listed below:

- Reliability Engineering and System Safety
- Journal of Quality in Maintenance Engineering
- Institution of Industrial Engineers,
- IEEE Transactions on Reliability
- International Journal of Quality and Reliability Management
- Journal of Condition Monitoring and Diagnostic Engineering Management (COMADEM)
- International Journal of Performability Engineering
- Journal of Logistic & computer science
- International Journal of Rock Mechanics and Mining Sciences
- International Journal of Surface Mining
- Journal of Mathematical and Computer Modeling
- SME (Journal of Society for Mining, Metallurgy, and Exploration, Inc.)
- European Journal of Operational Research
- International Journal of Reliability Engineering and System Safety.
- Naval Engineering Logistic

Editorial Advisory Board

- Journal of Quality in Maintenance Engineering
- International Journal of Performability Engineering
- International Journal of Condition Monitoring and Diagnostic Engineering and Management
- International Journal on Mineral Resources Engineering
- Journal of Mines, Metals & Fuels
- International Journal of Surface Mining
- Journal of Mining and Mineral Engineering
- International Journal of Mining Science and Technology
- Indian Mining and Engineering Journal



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