Good asset management ensures equipment uptime, asset longevity and safety (all of which are critical for operational excellence), and delivers the required performance at the lowest cost. However, good asset management requires modern tools, technologies and management systems with the appropriate features and functionalities.

Maintenance is an information-driven process and, keeping this in mind during the past few years, we have directed our strategic focus on the development of tools and technologies that address the industrial priorities expressed through data fusion, information sharing and seamless connectivity. Our goal is to facilitate the seamless linking of systems and equipment through our eMaintenance Lab, the processing of health data and reconfiguration of the state of equipment to achieve production goals. The driving forces have been the ever-increasing power and scope of information and communication technologies (ICT), which not only help in solving industrial problems in real time, but also create the right environment and databases for conducting theoretical research in maintenance.

Basic research in maintenance is somewhat akin to extreme sports if one considers the degree of uncertainty and the level of risk involved.

Further, our efforts of the past few years have resulted in establishing our Division as a leading and attractive partner for EU Framework Programmes mostly related to system reliability analysis and condition monitoring. Currently we are involved in many research projects which are approaching completion within the framework of EU FP 7 under different programmes.

Additional events of importance during 2014 include an eMaintenance congress and a number of industry-relevant workshops, seminars and courses, which were organized and coordinated from our two centres of excellence, namely Luleå Railway Research Center (JVTC) and the Center for Maintenance and Industrial Services (CMIS).

I am pleased to state that our achievements and growth since our establishment provide us with confidence and reassure us that we are on the right track. I must convey my sincere gratitude to all my colleagues in the Division for their commitment and effort as a team, as well as our partners from industry and the management of Luleå University of Technology for their trust, continuous support and guidance.

It gives me immense pleasure to present the Annual Report for the year 2014.

Dr Uday Kumar
Professor and Head
11th February 2015
March
Green and efficient transports
Luleå Railway Research Center conducted together with the Swedish Transport Administration a study in order to enhance market credibility by the continuous decrease of railway vulnerability, this in the project Bothiman Green Corridor (BGLC).

A link and effect model has been developed and used in a case study on track section Kiruna - Riksgränsen. This section is facing huge challenges since the capacity has to double by 2020.

June
Better planned track maintenance
Within the framework of ePilot119 program, which includes a track section between Luleå and Boden with various test equipment. Different research projects are initiated to test the viability of eMaintenance.

Luleå Railway Research Center, and focuses on implementation of eMaintenance within the railway sector. The first result obtained during the program was presented by Mohammed Taha from Trafikverket. The project resulted in a tool that is now used for trend analysis of maintenance work on tracks to improve utilization of reserved maintenance time-span.

June
Visiting the eMaintenance congress
The third Congress in eMaintenance was held in June at Luleå University of Technology. The conference, with focus on future maintenance, was visited by approximately 150 persons.

“...The conference is important for knowledge but also for networking...”
Bengt Göran Lahti, quality developer in the Air Force, was one of the visitors of the congress.

The availability to repair a JAS 39 Gripen and the resources that are needed for it depends on where in the world the plane is located and what type it is.

Ramin Karim, Associate Professor at Luleå University of Technology, works with so-called e-maintenance. The new information model that he develops, combines data on JAS39 Gripen from different information sources in new ways, and adjusts the maintenance solution to the context and the specific aircraft where the need for repair exists.

July
New technology for maintenance of aircraft
Researchers at Luleå University of Technology develops information models in cooperation with SAAB. The models give aircraft technicians’ transparent, real time maintenance information.

Dr Ramin Karim, Luleå University of Technology, presented his research at eMaintenance Congress in Luleå.

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October
Makes inspection of railway switches in manganese steel possible
In the EU-funded project SAFInspect has industry and academia together developed an ultrasonic method to allow inspections of rail switches of manganese steel.

Manganese steel is sometimes used in railway frogs to reduce wear. The disadvantage of manganese steel is that it is a coarser material, making it difficult to inspect using the conventional ultrasonic methods available.

Today no inspections of these components are conducted since reliable methods are missing. This can result in cracks that are never detected internally and in the worst cases, this could lead to a derailment caused by the bursting of a railway frog, says Matti Kantakallio.

The developed prototype will address the problem of detecting cracks in coarse-grained materials manganese steel, standardize inspections of railway frogs and create an inspection method in which the results can be compared with previous measurements to assess possible changes with time. The method was initially designed for the inspection of manganese steel but also works on the railway frogs of conventional steel or other components.

November
Internationally successful maintenance researcher awarded
Nordea Norrell Science Foundation award is given to one researcher every year at Luleå University of Technology for significant contribution to growth and development of region and society. The researcher must also be a good role model for the university.

This year the award was given to Uday Kumar for significant contributions to science, society and region.

“I am pleased and delighted to receive this award. It’s recognition for our research and innovation efforts of our group, says Professor Uday Kumar.

An Operation and Maintenance Production
Artificial Intelligence Tools: Decision Support Systems in Condition Monitoring and Diagnosis Hardcover
by Diego Galar Pascual
Artificial Intelligence is a methodology and a programming approach, developed, and still under improvement, for effective maintenance management through its use in condition monitoring. Artificial Intelligence is used in all kind of maintenance for industry machines. Because of the success in Condition monitoring, this book compiles and structures all AI tools used in CM in a reference handbook.
The Division of Operation and Maintenance Engineering was established as a new academic and research subject in the year 2001. The Division has progressed continuously towards establishing itself as a pioneer research group in the field of operation and maintenance engineering. With the increasing awareness among the industry and academia that maintenance ensures safe and sustainable performance and creates additional value into the business process, industries now have started considering maintenance as an integral part of the business process while applying a holistic view of the asset engineering and management.

The Division of Operation and Maintenance Engineering has gradually grown in size. By the end of the year 2014, the Division has 27 faculty staffs, 4 guest professors and 29 PhD students (including industrial and external PhD students).
2001 The Division is established
Division of Operation and Maintenance is established with Professor Uday Kumar as head. LKAB sponsor and maintenance research within the field of mining starts.

Takes the role as coordinator for big research center Luleå Railway Research center (JYTO) is now led and coordinated by the division, and the division’s research in Railway maintenance begins.

2002
Sponsors Professor in Maintenance
Swedish transport administration sponsors partnership in maintenance to build up research competence.

2003
Aviation in sight
The first research project is conducted together with SAAB Aerospace and the division starts their research in aviation maintenance.

Receives Licentiate degrees
When two of the division’s PhD students receives Licentiate awards in Operation and Maintenance they are the first in their research area at Luleå University of Technology.

2004
Iran as partner in education
Until now there is no undergraduate specialization in the subject area of Operation and Maintenance Engineering. However, the division starts an International MSc Engineering Program in Maintenance Engineering and Management in close co-operation with Sharif University of Technology.

2005
The first doctoral degree
Doctoral diplomas are handed out to the two first PhD’s in Operation and Maintenance at Luleå University of Technology.

eMaintenance becomes research subject
For the first time, research within the brand new area of eMaintenance is launched, this in a collaboration with SAAB.

2006
Center of Excellence CMIS is launched
To provide a neutral platform for cooperation among industries, academia and other stakeholders interested in the area of maintenance and industrial services, the center of excellence CMIS is established.

Organizer for international COMADEM
The division organizes the 19th International congress on Condition Monitoring and Diagnostic Engineering, called COMADEM. About 250 participants from 41 countries gather up in Luleå where the congress is held.

Launch of International Master Program
To meet the ever growing demand of European and Scandinavian industry, Luleå University of Technology launches the two year International Masters of Science program in Maintenance Engineering.

2007
Crossing the Atlantic
By starting a collaboration with Toronto University and University of Cincinnati, the division’s work crosses the Atlantic.

Program for Iranian industry
In order to improve maintenance competence, industry workers in Iran are educated in maintenance by the division.

2008
First PhD in eMaintenance
After a successful dissertation the first PhD in eMaintenance is examined.

2009
Grants from Strategic research council
The Division succeeds in getting grants from strategic research council of Sweden – establishing maintenance as a strategic area for research for Sweden.

2010
Develops Research Journal
The division launches Research Journal USA published by Springer.

First international congress on eMaintenance
The Division successfully organizes the first International Congress on eMaintenance, in Luleå, Sweden from 22-24 June, 2010.

2011
Number of staff duplicated
During the last 7 years the division has gained and doubled their number of employees from 25 to 50.

2012
First International eMaintenance laboratory
A unique laboratory for eMaintenance is established as the first in the world in order to facilitate different research and development activities.

Dominant on EU financed projects
The division receives their 12th EU financed project which gives the research subject highest success rate at Luleå University of Technology.

2013
Bachelor in Operation and Maintenance
The new Bachelor Programme in Maintenance Engineering has been developed together with the industry. During the first year 25 students from all over Sweden begins their education.

Organizer for the first MMPM Conference
Strategies and intelligent systems to assist companies to take control of expensive maintenance costs, are discussed by international companies and researchers at the new conference - Maintenance Performance Measurement Management.

2014
Technical expert for the Swedish parliament
When The Committee on Transport held a public hearing to shed light on choices facing the railroad, Uday Kumar was invited to talk about the latest maintenance research from a technical perspective.
The Operation and Maintenance group is involved in teaching at undergraduate, graduate and postgraduate programs. Additionally, every year a good number of seminars, workshops and Continuing Education Programs are organized for enhanced learning.

Education

The Bachelor of Engineering undergraduate Program and Maintenance Operation programs are organized for enhanced learning. Seminars, workshops and Continuing Education programs. Additionally, every year a good number of companies actively participating in this education providing summer jobs and seminars for our students. During 2014, 20 students have registered for our program.

The Operation and Maintenance group is involved in Leave to participate in our program.

The core research areas identified for strategic focus are:
- RAMS, LCC/LCP
- Condition Monitoring
- Remaining Useful Life Estimation
- Maintenance Decision Modelling
- Diagnostic & Prognostic
- Maintenance Information Logistics
- Maintenance Performance Measurement and Management
- Human Factors in Maintenance
- Design for /cost Maintenance

Projects within Operation and Maintenance research programs
During the last decade, the numbers of sponsored research projects in different areas of operation and maintenance have increased significantly. Our research group works in close collaboration with industries and prominent research groups active in the field of operation and maintenance engineering worldwide. The Division undertakes and works on applied research projects as well as on high-end development and consultancy projects from industry on a routine basis. We have continued to build the research program, adopting a distinctive interdisciplinary approach to meet short-term and long-term challenges faced by the industry and other organizations. The research activities are focused on integration of all operation and maintenance related issues at design phase.

Operation and Maintenance Engineering

Undergraduate Program (Bachelor of Engineering in Maintenance)
The Bachelor program in Maintenance Engineering started during 2013 fall with 25 students. The Introduction course to Maintenance Engineering is designed to provide both in-campus and distance students a foundation in basic maintenance and reliability Engineering. There are several large companies actively participating in this education providing summer jobs and seminars for our students. During 2014, 20 students have registered and joined this program. The Swedish military has also shown interest by giving their soldiers paid leave to participate in our program.

Graduate Courses
The Division is involved in teaching a number of courses at the Luleå University Technology’s Master in Engineering programs, like courses in Operation and Maintenance, which are offered to the students of Civil Engineering MSc programs, Sustainable Energy Engineering and Mining and Geological Engineering, besides the international exchange students. The Division also conducts courses in Mining Equipment Engineering and Mine Automation for the Mining Engineering students of the University. The Division has also been responsible for the courses in Mine Automation and Maintenance in the European Mining Program taught at Aalto University, Helsinki, Finland.

The following courses are taught by the Division of Operation and Maintenance Engineering:
- Applied Operations Research
- Reliability, Availability, Maintainability, Safety/Supportability/Sustainability/Survivability Research Program
- Life Cycle Cost (LCC) Theory & Application
- Applied Reliability Engineering
- Asset Engineering and Management
- Research Methodology in Engineering
- Risk & Reliability Analysis
- Stochastic Models for Reliability Analysis and Maintenance Optimization
- Stochastic Models for Reliability Analysis and Maintenance Optimization
- Advanced Reliability Engineering
- Foundation of Fuzzy Set and Fuzzy logic with Applications
- Operations and Maintenance - Hydropower
- Production Equipment Management
- Reliability and Maintenance
- Human Factors in Maintenance
- Reliability science deals with the understanding of the degradation process and reliability issues in the design stage. Reliability economics takes care of cost analysis of issues relating to design for reliability, and maintenance development. Reliability technology looks into technologies to sense and monitor system degradation, to collect and analyze relevant data for decision making. Reliability theory provides a tool to deal with all facets of reliability, engineering incorporating maintenance, economics, and management.

Effective maintenance theory and practice is applied to compensate the shortcoming in reliability by taking care of technological and economic issues. Maintainability deals with maintenance issues during the design stage, with an objective to facilitate easy and cost effective maintenance strategies so that the desired reliability can be guaranteed. Maintenance actions, if used properly can control the degradation and reduce or eliminate the likelihood of the occurrence of failures and to restore a failed system to its operational state. However, maintenance activities involve costs and these can be a significant fraction of the operating budget, like, around 5% in manufacturing industry, 10-15% in aviation industry, 15 – 20% in transport and 30% in mining industry.

Safety assessment of engineered objects forms the foundation for robust investigation of the risks associated with failures. The effectiveness of preventive and mitigating failure measures supports decision making regarding safety performances. The Division of Operation and Maintenance Engineering at Luleå University of Technology has been active in various aspects of RAMS4 Engineering.

RAMS4 methodology deals with function preservation and failure prevention during the design and operation phases of the asset’s life cycle. Each engineered asset (product, plant or infrastructure) is unreliable in the sense it degrades with age and usage and will fail ultimately. When a failure occurs, the severity of the consequences can be very significant — leading to higher maintenance, cost, and reduction in availability, economic loss, damage to the asset and environment and possible loss of human lives. Unreliability may also lead to annoyance and inconvenience leading to a lasting customer dissatisfaction that can create serious problems for the company’s marketplace position and reputation.

Interview

Malin Ygman, 27 years from Gällivare is one of our students at the BSc program in Maintenance Engineering.

- I chose to pursue distance studies because I like it in Gällivare and my hope is to find a suitable job here after graduation. The mining industry with the companies LKAB and New Boliden feels this current situation most enticing, and I hope that my skills as a Maintenance Engineer will be of great benefit in this industry.
Condition Based Maintenance Research Program

A careful implementation of Condition Monitoring (CM) and Condition Based Maintenance (CBM) Program offers significant potential for improving the effectiveness and efficiency of operation and maintenance of plants and infrastructures.

Our CM and CBM research program incorporates development of methods and models to assess the state of the item or components using on-line or off-line data collected from the item or components of interest. Diagnostics and prognostics are two important aspects in a CBM program. Diagnostics deals with fault detection, isolation and identification when a failure occurs. A prognostic approach deals with fault prediction before a failure occurs and tries to determine whether a failure is impending and estimate how soon and how likely a failure will occur. Diagnostics are a posteriori event analysis and will normally lead to a corrective maintenance action while prognostics are a priori event analysis which would result in preventive actions. Within the framework of CBM program, our main efforts are not only on development of methods and models but also to provide or establish scientific explanation of degradation mechanism leading to failure. We are also attempting to develop technologies to capture different degradation and also assess the state in real time. Some projects are in progress to assess the remaining useful life of components using data and other information collected by condition monitoring of the item of interest to develop context aware CBM program. The major sponsors of CBM research are Trafikverket, LKAB, SKF and VINNOVA among others. The smart bearing projects where hybrid models are being developed to estimate the remaining useful life are by SKF –UTC and VINNOVA within the framework of SKF-LTU University Technology Center (see page 26).

The concept behind the eMaintenance research program is to facilitate research, results and education in operations and maintenance activities by providing tools for advanced data mining and data analysis. We aim to assist the industry so that they could easily implement eMaintenance architecture and utilize our expertise for their maintenance, research and testing programs. One eMaintenance LAB has been developed and is located at Luleå University of Technology and a similar facility is developed for LKAB in Kiruna, Sweden. These labs are developed for online cloud computing application to feed data collected from industry from any outlaying location to the laboratories. Among the studies at the laboratory is a project to measure the impact of varying loads on track infrastructure and the performance and condition of wheels. These studies lead to estimate the remaining service life of the wheels and to predict when replacements are required. The results of this analysis are delivered to the client in a variety of ways; direct to handheld devices used by maintenance staff, or a pure HTML web-based interface, or an email. Through these Labs, we are trying to do is to build cooperation between industry, academia and research. We have also initiated International eMaintenance conferences, since 2010, in cooperation with the lab and industry partners and projects, the experiences of which are used for assisting and developing capabilities and experiences to facilitate further growth.

Our strategy is to provide artefacts (e.g. frameworks, tools, methodologies, and technologies) that address the industrial priorities expressed through ‘Data Fusion’, ‘Information Sharing’, ‘Seamless Connectivity’, and ‘Distributed Real-time Data Processing’. These artefacts will deal with challenges such as cross domain connectivity, communication capability, interoperability between ambient and distributed environments, data fusion, maintenance content management, data quality, information visualization, and real time distributed data analysis capability.

The goal of eMaintenance Research Program is to overcome shortcomings in the operation and maintenance system by looking at how to offer operators, maintenance staff, infrastructure managers and system integrators to access a real time computerized information system for real-time data to decision making.

“The market is finally ready for eMaintenance”

Laurence Earl, Head of Sales & Marketing at Saab AB, visited the eMaintenance congress during spring 2014. He sees opportunities with eMaintenance and the eMaintenance LAB.

-eMaintenance has great opportunities for development and the market is finally becoming ready. The Lab is a tool for utilization of research which makes it possible to test and evaluate scenarios and ideas and develop prototypes. This means that you can visualize an idea, show it to the market and then take the working ideas in to production.
Human Factors is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and other methods to design in order to optimize human well-being and overall system performance (IEA, 2000). We aim to assist maintenance organizations in railway, mining, aviation, process industry, hydropower, to increase their competitiveness through the implementation of Human Factors principles. This is achieved by the improvement of maintenance work processes, reducing human error, improving cognitive awareness, and decreasing mental workload during maintenance activities.

The Human Factors program presently consists of projects dealing with:
- Human error in a maintenance context
- Physical ergonomics
- Cognitive ergonomics
- Visual ergonomics

Effective Maintenance Execution with Human Factor Interventions
This project focuses on developing easy to implement guidelines for good maintenance practices through Human Factors interventions.

Decision Support Data for Aircraft Maintenance Personnel
The goal of this project is to develop context based decision support for aircraft maintenance personnel. This includes the visualization of necessary maintenance information, the reduction of cognitive workload and reducing the risk for human error.

Graphical User Interface for Railway
This project developed a graphical user interface to display the condition of train car wheels on a Windows tablet.

Guidelines for Applications for Maintenance
This project developed User Interface cognitive and physical ergonomic guidelines for Windows tablet applications.

Decision Support Helps for Aircraft Maintenance Technicians
This project studied the workplace of aircraft maintenance technicians, which resulted in recommendations for assistive tools that could be developed, as well as, presented ways to reduce the risk for human error.

Visualization of Condition Data Regarding Hydropower Plants in the Luleå River
This project developed a web based interface that assists maintenance personnel in monitoring the condition of a hydropower plant based upon advanced operation and maintenance data.

Visualization of Maintenance Information in the Context of an Operational Aircraft
This project is in the process of developing a decision support tool using Google Glass and picture recognition technologies for aircraft maintenance technicians.

Augmented Reality Headset for Aircraft Maintenance
A headset designed for augmented reality support, a physical non-working prototype, was developed so that the physical ergonomic aspects could be tested.

Tablet Based Web Graphical User Interface for Aircraft Maintenance Personnel
The goal of this project was to reduce the aircraft maintenance technician’s workload and reduce the amount of paperwork. This resulted in a tablet based Graphical User Interface designed for the specific needs of military aircraft maintenance technicians.

The goal is to continuously improve the work place for both operative and maintenance personnel therefore we will continue to work with Human Factors issues that improve the whole lifecycle of an asset.
The strategic focus of the research program is to ensure increased availability, capacity and sustainability of the railway network and rolling stocks by effective operation and maintenance. A long-term management of the transport system requires a maintenance system based on well thought and elaborate systems of rules, maintenance strategies, maintenance concepts and descriptions of how the selected measures and their costs can be linked to the effect achieved in the system’s capacity. Concepts such as reset capability, maintenance security and dependability are especially important when the facilities are utilized close to their maximum capacity. It is important to find new ways to design regulatory systems and maintenance strategies that allow innovation while maintaining risk and safety. The regulatory system should cater for at least maintaining security but also allow for innovation and dynamism.

The strategic focus of the railway research program, which is conducted within the Luleå Railway Research Center (JVTC), is to develop new tools, methods and models that will facilitate innovative solutions to railway problems related to operation and maintenance.

Since Sweden is a mining and industrial country, the mining operation and machineries are attractive research topics, especially in the north. Mining is one of the main research topics in the Division of Operation and Maintenance Engineering. Many research projects related to mining machineries and production systems have been undertaken and are in progress. In addition, in line with industrial demand and future vision, several research proposals were prepared to apply for EU (Horizon 2020), international (ERA-MIN and NordMin) and national (VINNOVA) funds.

**Mining Research Program**

**Ongoing projects**

**Mine Production Assurance Program (MinePAP)**

Production assurance program (PAP) which has been developed in oil and gas industry has been selected as a core idea for this research. To guarantee the desired production level the production bottlenecks need to be detected, uncertainties be controlled, and the dynamic interaction of dominant parameters in production system be modeled and analyzed. In 2014, a new measure called Mine Production index (MPI) was developed as a tool for evaluation of equipment effectiveness in mining operation system. Considering this index, a new framework was developed to analyze and detect the production bottlenecks in mine which is a part of whole MinePAP. For performing a systematic analysis and modeling of the production process in mines, in 2014, the system dynamic (SD) modeling technique was used. The dominant factors in mine production systems were selected and the causal loop and stock and flow diagrams were built. Defining of the production functions based on the case studied data is ongoing.

**remaining useful life (RUL)**

Weibull proportional hazard model (PHM) with time-independent covariates such as operator skill, dust and temperature were used to model the actual hazard function of machineries. Using this model the system operating environment is integrated in the reliability analysis and then remaining useful life (RUL) estimation of system. The model is verified and validated using data from the hydraulic system of an LHD fleet in a Swedish mine.

**Rock and Machine Interface**

The main objective with this project is to evaluate geomechanical rock mass responses using Measurement While Drilling (MWD) technique in open-pit mining. Recent research reveals that, specific energy, as one of the studied parameters, is affected by not only rock mass characteristics but also operational parameters. Further, in 2014, MWD data was used to assess the life length of the rotary tricone bits. Results show that, the operational parameters need to be optimized and be more adjusted by rock mass characteristics in studied mine.

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SAFTInspect - Ultrasonic synthetic aperture focusing technique for the inspection of railway crossings.

SAFTInspect aims to develop an affordable and reliable ultrasonic inspection solution for sections of high manganese steel rail crossing points, which are used in European railways. A non-destructive testing (NDT) inspection solution will be developed in the project to facilitate early defect detection of crack defects at safety critical locations. The project results will increase industrial confidence in NDT by achieving better quality levels in the identification, classification and sizing of defects compared to existing techniques. The automated output will increase efficiency and reduce scanning mistakes associated with manual methods. The rapid, automated solution will reduce time required for personnel to be located in potentially hazardous environments. This will provide NDT workers with safer, healthier and better working conditions in European industry related inspection and maintenance activities. The proposed project will focus on the rail transport industry within the EU. However techniques developed by the project would not be specific to high manganese steel rail track, but applicable to many other coarse grained, anisotropic or non-homogeneous materials.

Branch Programs

Ongoing projects

Top of Rail lubrication.

Trafikverket and LKAB have installed the first Top of Rail (ToR) Lubrication equipment to investigate if the systems lubrication is working in cold climate. This was conducted during 2013 in two different places on the Iron Ore line. The project will show if the ToR lubrications will increase the rail wheel forces.

Improve availability and reduced life cycle cost of track switches

Track switches are critical units in railway systems, as they perform the switching procedure that guides trains along different routes. To maintain their functional requirements there is a need to predict the track geometry change affected by different operating and ambient conditions.

This project contains several case studies where measurements has been performed on the Swedish infrastructure, to determine long term track geometry changes seen in fig. 1 and the effect of different load conditions related to the vertical deflection of the track seen in fig. 2.

The knowledge gained in the project will be finalized by developing new concepts of turnouts that need less tamping and LCC model taking into account diagnostics data from track recording cars (used in Sweden). The effects obtained from the project include:

- Evaluation and development of measurement methods for measurement of track geometry changes over time and measurements of dynamic displacement on rail;
- New concepts of turnouts which needs less tamping;
- Development of a LCC model which take tamping results and costs into account.

Maintenance Thresholds

In the past, railway maintenance procedures were usually planned based on the knowledge and experience of the company involved. The main goal was to provide a high level of safety, and there was little concern for economic issues. Today, however, the competitive environment and budget limitations are forcing railway infrastructures to move from safety limits to maintenance limits in order to optimize operation and maintenance procedures. By discussing maintenance limits instead of safety limits, the focus is expanded to comprise both operational safety and cost-effectiveness for the whole railway transport system.

Using maintenance limits mean balancing maintenance performance against economics with a view of achieving the estimated service life and delivering the function required at the right price. A methodology to optimize track geometry maintenance by using historical geometry data has been developed and is being tested. The methodology is based on reliability and cost analysis and facilitates maintenance decision-making process to identify cost-effective maintenance thresholds.

Link and Effect model

The aim of the study is to develop a link and effect model to improve the total effectiveness of the maintenance system for railway infrastructures. The link and effect model is a performance measurement system that combines performance measurement and engineering principles for proactive management of physical assets.

ePilot119

ePilot19 is a pilot project undertaken in cooperation between Luleå Railway Research Center (JVTc) at Luleå University of Technology (LTU), Trafikverket, railway companies, maintenance contractors for vehicle and infrastructure as well as suppliers and consultants. The project will run between 2014-16 on track sections 119 between Boden and Luleå. Since 2005, work has been conducted within the JVTc with the aim of using different types of condition based data to develop a decision support. This in order to take preventive measures in the railway system before errors and disturbances occur. Working with prevention rather than corrective action is a more cost effective way to conduct maintenance activities. ePilot19 provides a collaboration platform (demonstrator) for the development of solutions for maintenance decision support. The support is based on the needs and requirements from various stakeholders in order to enable and transform the Swedish fragmented rail industry to an integrated system. The solutions should result in improved punctuality and minimized disruption in rail services and an insurance of greater accessibility and quality together with more efficient maintenance.

It is a cross-organizational area based on information logistics to ensure that maintenance is carried out in line with both the customer and the supplier’s business objectives to take care of the inherent elements in all parts of a system’s lifecycle. There is a strong link between the infrastructure and the vehicles that use it. By using condition-based data from across the railway sector and its stakeholders a good basis is established to take the right decision at the right time. The approach is based on enhanced collaboration methodology with a framework project and a support team that is cohesive for smaller subprojects within the framework project.

Maintenance provides better sleep on trains

Project ePilot119 with Luleå University of Technology, Swedish Transport Administration and others have in research on improved train maintenance been able to develop methods to measure and monitor the vehicles’ status. It’s about being able to measure wheel wear while the train is running and thus be able to predict when it is time to replace the wheel before it starts to vibrate.

- Somewhat simplified, one could say that in the future rail passengers would not have their deep disturbed in wagons that shaker or wobble caused by worn wheels, says Kajani Karin, Associate Professor at Luleå University of Technology, who leads ePilot19.

Damill AB has with advanced measurement technology developed a solution to measure wheel wear at an early stage.

- That solution allows us to measure the wheels wear and automatically connect data to the right vehicle and the right axle in a train even though it passes at full speed, says Dan Larsson, CEO of Damill and one of the actors in the network within ePilot19.

According to the client SJ, the solution means that it’s possible to maintain wheels in the right time to make the maintenance more efficiently, which in turn increases safety.
When dealing with such complex technical systems, it is critical for air carriers to achieve high standards of safety and reliable services, at lowest possible life cycle cost. This needs to be supported through an effective maintenance solution which ultimately can enhance the aircraft’s capability to meet market demands at the lowest possible cost. Hence, it is critical to introduce a product lifecycle management (PLM) program for the fleet throughout its whole lifecycle, where, issues such as dynamic maintenance program, spare part planning, fleet management and phase-out program arise.

Moreover, in today’s global business scenarios, it is necessary to implement an eMaintenance solution to provide information services that support the maintenance of complex technical systems. In addition, when dealing with such complex technical systems with long life cycles, the management of RAMS-related information is crucial to fulfill stringent dependability, Life Support Cost (LSC) and safety requirements. The aviation research program is committed to enhance the effectiveness of aircraft operability considering future demand and service models.

### Ongoing projects

#### AIRCRAFT MAINTENANCE PROGRAMME DEVELOPMENT

The purpose of this research program is to develop decision support methodologies and tools for aircraft scheduled maintenance program development. The results will facilitate decision making in maintenance to achieved high level of safety and aircraft availability in cost effective way. The aviation program is dedicated to RAMS, Data Mining and information logistics in aviation context.

#### MAINTENANCE SOLUTIONS FOR EFFECTIVE DECISION-MAKING IN MAINTENANCE

This project aims to explore and describe how the information logistics in support of decision making can be established. Data and information from the technical facilities that describe state and state changes should be gathered and presented so that decisions on necessary measures can be taken. The project will further develop skills and expertise in eMaintenance, at field scale in the JAS Gripen, Saab Aerotech based on the earlier case studies from Banverket and Vattenfall Hydropower.

#### ENHANCED LIFE CYCLE ASSESSMENT FOR PERFORMANCE-BASED LOGISTICS

To improve the competitiveness of the Swedish aerospace industry, it has become increasingly important to ensure the availability and reliability of analyses based on the heterogeneous data sets that are generated during the life cycle of airborne platforms and their support systems. The purpose of this research program is to develop methodologies, tools and models to facilitate implementations of performance based logistics (PBL) concepts in maintenance with cost effectiveness.

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### Road Research Program

Sustainable road transports are dependent on smart and innovative solutions to cope with an increase in the flow of goods while reducing the harmful effects on the environment.

Demand for better maintenance, lower energy use, and increase in the capacity of existing transportation systems will be required. The transport of goods and people on the road must function equally well in winter, spring, summer and autumn. Especially in the northern part of Sweden, the basic industry (forestry, process, steel, and mining industry) is dependent on efficient transportation. The operation and maintenance research group at LTU is engaged in the development of Condition Based Maintenance (CBM) solutions for the road sector. High Capacity Transports (HCT) is one area of application of the research within sustainable transportation. For heavy trucks (gross weight above 60 tons) there is a need to increase the knowledge and the empirical basis for the effects on road deterioration and maintenance. The research is focused on the bidirectional relationships between the effects of heavy vehicles on road deterioration and vehicle operating costs (e.g. tyre wear, fuel consumption and maintenance), operating conditions (e.g. speed and load), amount of freight transported and greenhouse gas emissions. One objective is to develop techniques for monitoring the road surface condition and road/tyre interaction. A fundamental road quality indicator measured is roughness, for which there are well established road user and environmental effects, e.g. fuel consumption, spare part costs and tyre wear. Of importance is also to monitoring tyre inflation pressure as well as to consider wide single tyre or dual tyre assemblies, which significantly affect road wear and fuel consumption.

Another application of the CBM research is for mine haul roads and ramps, which are the lifeline of both surface and underground mining. The constant demand for increased production efficiency motivates the development of new effective tools for better road maintenance planning. The management of haul roads requires relevant indicators for the condition of the asset. Online and integrated condition monitoring systems, data communication, and maintenance decision supports are essential needs for modern mining operations.

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### Manufacturing Research Program

The direct and indirect cost of maintenance in the manufacturing industry is too high to ignore. Hence, it is important to increase the scientific and applied knowledge related to maintenance in manufacturing in order to improve the competitiveness of the industry.

It is a known fact that maintenance requirements are often not considered until the late design phase even though the worst impact on maintenance and thereby life cycle costs would come from operational and maintenance requirements as early as possible. Maintenance issues should be considered during all the three phases of a product life cycle, namely the Engineering Design phase, Manufacturing and Assembly phase and Product Application phase. Some of our projects related to manufacturing sector aim at integrating maintenance thinking in all the three phases of a product or a system life cycle generating a firm base for higher productivity, lower production costs and better industrial design through scientific analysis. The manufacturing research program was initially funded by NSF through InMaint project within the framework of manufacturing program. Proviking together with manufacturing companies like Sandvik, Parker Hannifin, etc. During the last year manufacturing program was supported by Atlas Copco among others etc with focus on Mining drill rigs.
Studies by the Universities and industries have shown that a company can cut energy consumption in its plant by five to ten percent depending on their preventive maintenance practices. Some of the energy savings in mechanical systems would be defined by the type of preventive maintenance performed on some of the basic mechanical components. For example, on the accuracy of couplings alignment; a small misalignment by even 0.003” can lead to energy loss through the coupling displayed as heat energy. Another type of energy loss is through improper bearing lubrication. If bearings have excessive lubrication, it requires more energy to churn the lubricant, increasing the fluid friction in the lubricant and overheating of the bearing. The opposite problem is insufficient lubricant, which results in excessive frictional resistance of the bearing (from metal to metal contact) and overheating of the bearing. Poor preventive maintenance practices will easily contribute a 5% to 10% energy loss for mechanical power transmission. Other examples are: air leaks requiring compressors to run more than necessary asking additional energy for the compressors to operate unnecessarily; hydraulic system wastes are generally related to leaks. These, and other energy losses, easily will account for energy losses of five to 15 percent in hydraulic systems. These savings projection need to be applied to cost cuttings and increasing the “Green” focus for industry.

Managing asset sustainability effectively can support the organizations to enhance their competitive position and create additional value. Industries are major contributors of the social, environmental and economic issues of the society, and many of them have initiated sustainability drive to reduce the negativity of environmental, energy consumption and other social issues. Achieving a sustainable development needs strategic and continuous efforts involving the entire organization, where maintenance efforts play an important role. The management needs to understand and develop an appropriate strategic approach to understand the challenges involved and preparing all involved groups and personnel to achieve the sustainable development through application of maintenance performance measurement. Keeping these aspects in focus, our Division is collaborating with industry and funding agency to share its research expertise in energy saving and sustainability drive.

Energy Research Program

To compete and survive in the 21st Century, companies are focusing more and more on green or sustainable initiatives.

Luleå University of Technology has identified nine areas of excellence in research and innovation. One of them, named Sustainable transportation, is led by the division.

Sustainable transportation

The future of sustainable transport will depend on smart and innovative solutions to cope with an increase in the flow of goods at the same time as it will reduce the harmful effects on the environment and climate. Demand for better interoperability between different modes of transport, better maintenance, lower energy use, as well as an increase in the capacity of existing transportation systems will be required. The transport of goods and people must function equally well in winter, spring, summer and autumn.

At Luleå University of Technology, research is focused on vehicle technology, maintenance systems, and vehicle testing operations in cold climates, road engineering and space technology.
Luleå Railway Research Center (JVTC),
www.jvtc.ltu.se

JVTC is a collaborative research center at Luleå University of Technology (LTU) in Luleå, Sweden. It was established in 1998 by the former Swedish Railway Administration (Banverket), the LKAB ore transport company (MTAB), Öresund Rail and Luleå University of Technology amongst others. The main purpose of the center is to co-ordinate the railway research being pursued at different Departments at the University and to facilitate the contacts between researchers, companies and the railway sector in general.

Through international co-operation with other centers, institutions, universities and companies, a platform has been built for the development of an efficient and environmentally friendly railway transport system. The main focus of the Research Center is to provide solutions to maintenance problems to facilitate smooth running of railway transport system. The center operates under the aegis of the president of Luleå University of Technology. The center is currently headed by Prof. Uday Kumar and funded by industry.

SKF University Technology Center (UTC) for Advanced Condition Monitoring
www.ltu.se/centres/ SKF-LTU-University- Technology-Centre

The UTC is a collaboration between SKF and three divisions at Luleå University of Technology: Operation & Maintenance Engineering, Machine elements and EISLAB. The idea of the center is to develop advanced concepts for condition monitoring of smart machinery equipment. SKF's visions for establishment of the center are to develop a "thinking machine", in order to create systems that are active and independent instead of passive. "Thinking machines" can reconfigure themselves in smart way during operation, thereby prevent costly downtime.

The center is governed by a framework agreement between the University and SKF, which lasts for an initial period of five years. The funding from SKF supports day-to-day operation of the center and a number of PhD researchers who work on UTC projects.

Center for Maintenance and Industrial Services (CMIS)
www.cmis.ltu.se

CMIS is a collaborative platform initiated by Luleå University of Technology in close cooperation with industrial partners. The business goal of CMIS 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. CMIS undertakes various activities to promote dialogue and interaction in an effort to understand the engineering support requirements of industry.

CMIS organized many seminars and workshops for this purpose. Leading professors and expert from Canada, Australia, and India 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. Today, CMIS has more than 15 industrial partners.

Maintenance Research Laboratories

The division has established the eMaintenance and CBM lab. Besides these two labs we also work in close cooperation with other laboratories such as, EISLAB (Embedded Internet Systems Laboratory), Tribological laboratory, etc.

Condition Based Maintenance Lab (CBM LAB)

In our new CBM lab (Condition Based Maintenance), research and training in condition-based maintenance is conducted with a view towards future requirements. In the laboratory, which has a focus on condition monitoring of railway and mechanical equipment (gears, bearings, etc.) is currently a test rig for condition monitoring of cracks in the gear as well as an advanced test rig for condition monitoring of various sizes and types of gearboxes charged with realistic torque and speed. In addition, a model railway with locomotives and cars with the, in it’s context, unusually large track width 45 cm, which is used for training purposes and for scale testing. The laboratory also possesses measuring equipment for condition monitoring of rail and track switches.

eMaintenance LAB is the world’s first international laboratory for eMaintenance.

Wheel Profile Measurement Station

Trafikverket and LKAB have installed the first high speed wheel profile measurement system for railway vehicles as October 2011. The system is located on the Iron ore line in the northern part of Sweden. This is a part of a project to improve the maintenance of rolling stock and infrastructure. The information from this system goes to eMaintenance LAB at Luleå Research Center (JVTC) for processing and for research. The iron ore transport operator uses the wheel profile measurement system to detect wheels which fall outside the safety and maintenance limits. The wheel profile measurement system consists of four units with lasers and high-speed cameras. The WPMS extracts the parameters at flange height, flange width, flange slope and tread hollowing. After four years in operation the systems shows good measurements accuracy and reliability.

CMIS undertook various activities to promote dialogue and interaction in an effort to understand the engineering support requirements of industry. CMIS organized many seminars and workshops for this purpose. Leading professors and expert from Canada, Australia, and India 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. Today, CMIS has more than 15 industrial partners.

The measurement station is Sundborn is used for wheel profile measurements.

Luleå Railway Research Station

To stream line data collection to meet research requirement, JVTC has established a measurement station to measure forces exerted by vehicles on the track. The measuring pattern of sensors at measurement point separates the vertical and lateral forces. The measured data are automatically transferred to the eMaintenance LAB using internet for processing it into useful information and knowledge that can be used by train operators and infrastructure managers. Some of the highights of this measurement station are: delivers real time data 24 hours a day, identifies trains and wagons, a top 10 list of poorly performing track and internet access to real time data. The real time data after processing is displayed in real time in a user friendly manner.

Our collaborative Research Centers

Luleå Railway Research Center (JVTC), www.jvtc.ltu.se

CMIS is a center of excellence in mining and metallurgy established in 2009, and funded by strategic grant from the Swedish Government. The aim of CMIS is to build world class research within mining and metallurgy with focus on sustainable use of natural resources. There are six research work packages within the framework of CMIS and our Division is responsible for work package of "Lean Production". Other research work packages are: Geometallurgy and 4D Geological Modelling; Deep Mining; Particle Technology; Green Mining and Raw Materials for future iron and steel making.
International Research Collaboration and Networking

To strengthen research and education and their quality, a strong network with all related active research groups, nationally and internationally is essential. Keeping this in view, we have created formal and informal networking and collaboration with research groups with universities and industries outside Sweden. The universities and Research Institutes are: Aalto University, Finland; Birmingham University, UK; Central Queensland University, at Gladstone, Australia; Indian Institute of Technology (IIT) Bombay and Kharagpur, India; Kemi Tornio University of Applied Science, Finland; Queensland University of Technology, Brisbane, Australia; Tromsø University, Norway; University of Cincinnati, USA; University of Queensland, Australia; University of Stavanger, Norway; University of Toronto, Canada; VTT, Helsinki, Finland; University of Valencia, Spain. The Industries are: Airbus, France; ALSTOM Transport, France; ABB, Sweden; ProRail, The Netherlands; Network Rail, UK; LKAB; Boliden AB; Saab Aerospace and Trafficverket, Sweden. Our Division is one of the initiating members of the European Research Network on Strategic Engineering Asset Management (EUREN-SEAM) and involved with European National Maintenance Society (EFNMS).

Center for Intelligent Maintenance System (CIMS)
The Division of Operation & maintenance Engineering is having close collaboration in maintenance area with the Center for Intelligent Maintenance Systems at University of Cincinnati, USA. In order to strengthen the collaboration, University of Cincinnati has invited and appointed Prof. Uday Kumar as a Guest Professor. Professor Jay Lee, Director IMS is also appointed as a visiting Guest Professor at the Division of Operation & Maintenance Engineering, Luleå University.

University of Queensland Australia
Professor Pat Murphy from the University of Queensland, Brisbane, Australia is a Guest Professor at the Division of Operation & Maintenance Engineering, Luleå University of Technology. He has been actively participating in teaching post graduate courses and conducting workshops and seminars since the year 2009.

Central Queensland University
Within the framework of MoU signed between Luleå Railway Research Center and Centre for Railway Engineering, Central Queensland University (CQU).

Top of Rail
Research team for friction measurement on IORE locomotive. TOR friction modifier can eventually reduce the maintenance costs of the railway.

Events 2014

Team-building in Storforsen
During late August the division met up in Storforsen for a team-building.

eMaintenance congress 2014
The bi-annual eMaintenance congress was held mid-June. Over a hundred people visited the event. The social program consisted of an appreciated tour of the World Heritage Church Village in Gammelstad.

The group gathered in world heritage church village Gammelstad for a guided tour.

A welcome speech is also held by Uday Kumar, professor and head of the Division.

During the day there were short breaks for socializing in between the sessions.

Vice Chancellor and Professor Johan Sterte welcoming all guests to the congress.

Agricultural and Natural Resources Council of Queensland
The AWRM congress was held mid-June. Over a hundred people visited the event. The social program consisted of an appreciated tour of the World Heritage Church Village in Gammelstad.
COMADEM 2014 was held during 16-18 Sep 2014 at Brisbane, Australia. Our Division was involved in this conference from organizing and conducting part.

Study Tour

Ud41 Students from campus and on-distance from Luleå, Umeå and Mitt University studied DOO04B Hydropower Operation and Maintenance during LP4, 2014. These students visited the hydropower stations near Jokkmokk in two groups during May 2014, besides contact program at Jokkmokk training center.

Best European Masters Thesis Award in Maintenance

Professor Uday Kumar and Associate Professor Aditya Parida were involved and revived the European Federation of National Maintenance Societies (EFNMS). The photograph shows the joint winners of the Best Master’s thesis during EUROMAINTE-NANCE 2014 at Helsinki with Prof Uday Kumar, Chairman and Aditya Parida, Secretary of the EFNMS thesis award committee. President of the Conference and Treasurer, Salvetti Foundation.

Sweden and Japan starts cooperation

An agreement for cooperation on high-speed railway technology is signed between Sweden and Japan.

Licentiate Degree Awardees

Matthias Asplund

Title: Wayside Condition Monitoring Technologies for Railway Systems.

The licentiate is about how information from the automatic wheel measurement system and camera inspection of switches and crossings can give information for the infrastructure manager to prevent failure driven capacity consumption on track.

Amparo Morant

Title: Dependability and Maintenance Analysis of Railway Signaling Systems.

This licentiate thesis explores the areas that could improve the performance of railway signaling systems during the operation life cycle phase, by enhancing their dependability.

Amol Lanke

Title: Mine Production Index – Development and Application

The focus of this research is production assurance for mining industry. In this direction the thesis elaborated that production assurance program from Oil and gas industry can be used as a guideline for the mining industry.

Urko Leturiondo

Title: Synthetic Data Generation for Hybrid Prognosis Models.

In this research work, an emphasis has been placed in physical modelling, applied to the field of rolling element bearings.

Emilio Rodríguez Martínez

Title: Track Circuits’ Robustness – Modeling, Measurement and Simulation

The thesis is based on the EU finance project TREND. This research consisted on modeling and simulation of the train and railway infrastructure to find the worst case scenarios and its validation on the track and in the lab.
Mikael Palo
Title: Condition-Based Maintenance for Effective and Efficient Rolling Stock Capacity
Assurance A Study on Heavy Haul Transport in Sweden
By using condition data from observations, along with diagnostics and prognostics, an effective condition-based maintenance strategy can be planned effectively and executed efficiently.

Hussan Hamodi
Title: Reliability and Life Cycle Cost Modelling of Mining Drilling Rigs
The purpose of the research performed for this thesis has been to develop methods that can be used to identify the problems affecting drilling rig downtime and to identify the economic lifetime of drilling rigs.

Christer Stenström
Title: Operation and maintenance performance of rail infrastructure: Model and Methods
In this thesis, a link and effect model for monitoring and analysis of operation and maintenance performance of rail infrastructure is developed. The model includes various methods for analysis of operation and maintenance data. The work aims to facilitate improvements and optimisation of decision-making in railways.

Research Projects

**eMaintenance infrastructure for enhanced information logistics**
**Sponsors:** Vinnova & Saab Support Service
**Researchers:** Olof Candell, Alireza Ahmadi & Ramin Karim
**Objective:** The project aims to improve the infrastructure for data and information exchange between operators and suppliers to identify, adapt and integrate ICT-based methods and solutions for an eMaintenance system.
**Duration:** 2009 – 2014

**eMaintenance solutions for effective decision-making in maintenance**
**Sponsors:** Swedish Transport Administration, Vattenfall Vattenkraft, Vattenfall Services & Saab Support Service
**Researchers:** Mustafa Aljumaili, Yasser Ahmed Mahmoud, Olof Candell & Ramin Karim
**Objective:** This project aims to explore and describe how the appropriate information logistics as support to the production of the maintenance process can be established.
**Duration:** 2009 – 2014

**eMaintenance solutions for predictive maintenance support**
**Sponsor:** Kamatsu
**Researchers:** Liangqin Zhang, Ramin Karim & Philip Tretten
**Objective:** The research aims to develop a concept that facilitates maintenance service provisioning through enhanced use of predictive maintenance based on on-line data collection and distributed data analysis.
**Duration:** 2013 – 2014

**Enhanced Life Cycle Assessment for Performance-Based Logistics**
**Sponsors:** Vinnova (NFFF-5), Saab Support Service and Luleå University of Technology
**Researchers:** Jan Block and Alireza Ahmadi
**Objective:** The purpose of this project is to develop methodology, tools and models to facilitate implementation of performance-based logistics (PBL) concepts in aviation maintenance.
**Duration:** 2009 – 2014

**Context-driven maintenance decision support in eMaintenance**
**Sponsor:** Vattenfall
**Researchers:** Liangqin Zhang, Ramin Karim & Philip Tretten
**Objective:** The objective of the research is to acquire, integrate, analyze data from heterogeneous, decentralized data sources and extract valuable patterns from the chaos of data for supporting maintenance decision in hydro power plant.
**Duration:** 2013 – 2014

**Hybrid models for machinery diagnosis and prognosis**
**Sponsor:** SKF
**Researchers:** Madhav Mishra, Juhani Saita, Diego Galar, Matti Rantala & Uday Kumar
**Objective:** This research strives to improve the diagnosis and prognosis of the RUL (Remaining Useful Life) of an asset by the development of hybrid models.
**Duration:** 2013 – 2017

**Risk-based inspection interval for railway infrastructure**
**Sponsor:** Swedish Transport Administration
**Researchers:** Alireza Ahmadi, Peter Söderholm and Uday Kumar
**Objective:** The objective is to evaluate the application of MSG-3 methodology to assess the susceptibility of railway track to the different forms of structural deterioration, in different operational & environmental conditions.
**Duration:** 2012 – 2014

**Efficient Performance Based Air Vehicle Maintenance**
**Sponsor:** VVINNVA (NFFF-6), Luleå University of Technology, Saab Support and Services, Saab Aeronautics
**Researchers:** Alireza Ahmadi and Jan Block, Arne-Hanssen Garnåstak
**Objective:** To develop decision support methodologies and tools to enhance the Fleet Availability at minimum cost through maintenance process within Performance-based Logistic Concept.
**Duration:** 2013-2016

**Improvement of Railway infrastructure Capacity through effective Maintenance Practices**
**Sponsor:** Luleå Railway Research Center (JVTC)
**Researchers:** Stephen M. Farnsworth, Matthias Asplund, Matti Rantala & Uday Kumar
**Objective:** The objectives of this project are to develop maintenance decision support models and deploy effective condition monitoring systems for critical items to reduce maintenance possession time.
**Duration:** 2010 – 2014

**Lean Mining**
**Sponsor:** Center of Advanced Mining and Metallurgy (CAMM)
**Researchers:** Uday Kumar, Berndt Ghodrat, Hadi Hoseiniv, Arno Lanke, Håkan Schunesness & Jan Johansson
**Objective:** The goal is to build a state of the art research capability in the area of mine production system by focusing on the subprojects addressing the critical issues to realise the vision of lean mining system.
**Duration:** 2010 – 2014

**Study of Maintenance Thresholds for railway track and vehicles**
**Sponsor:** Swedish Transport Administration
**Researchers:** Imam Ardesteh Khoy & Per-Olof Larsson Kråk
**Objective:** The outcome of this research will be in the form of a maintenance decision support model to specify cost-effective maintenance thresholds for railway track and wheels.
**Duration:** 2009 – 2014
Integrated Reliability Analysis for Maintenance Strategies Optimization
Sponsor: Luleå Railway Research center, JVT
Researcher: Janet Ljung Lin
Objective: This study aims to develop new models for integrated reliability analysis, by which to support decision making on maintenance strategies optimization.
Duration: 2012 – 2014

Remaining Useful Life Estimation of Mining Machinery
Sponsor: Boldmin Mineral AB
Researchers: Fatemeh Almazadeh, Jan Lundberg & Berhad Ghodrati
Objective: To develop a neural network that is capable of predicting the Wear of liners in mining mills.
Duration: 2013 – 2014

Optimum maintenance and LCC of mobile drilling machines in mining applications
Sponsors: Federal Govt. of Iraq, Atlas Copco & Boldmin Mineral AB
Researchers: Hussein Hamoudi, Jan Lundberg & Berhad Ghodrati
Objective: This research aims to reduce downtime of drilling rigs which are used in underground mines. The research is also dealing with economic: life time of mining drilling rig. This study aims to identify the replacement age of drilling rigs from an economic point of view.
Duration: 2011 – 2014

RAMS analysis of railway signalling systems
Sponsors: Luleå Railway Research center (JVT) & Swedish Transport Administration
Researcher: Anmpaar Murant
Objective: This research analyses the dependability and maintenance of railway signalling systems and proposes various approaches to improve maintenance performance.
Duration: 2012 – 2015

New technology for control and life cycle cost of track switches
Sponsor: Swedish Transport Administration
Researchers: Jens Jönsson, Jan Lundberg & Matti Rantatalo
Objective: The Swedish railway infrastructure manager faces challenges of demands on increasing traffic capacity and thus improvement of the switches and crossings (S&C). The aim is to identify important conditions that can improve availability and reduced life cycle cost of track switches.
Duration: 2011 – 2016

Rock and Machine Interface
Sponsor: Center of Advanced Mining and Metallurgy (CAML)
Researchers: Rajib Ghosh, Niklas Schumann & Uday Kumar
Objective: The objective of this project is to understand and communicate rock mass behavior in real time with a special reference interface between rock masses/rock bodies and production machines.
Duration: 2012 – 2017

OptiKrea - Optimal methods for innovative product development and decision support
Sponsors: Vinland Nordic Switch Systems, Swedish Transport Administration & Infranord
Researchers: Anna Molos Petersson, Matti Rantatalo, Jan Lundberg
Objective: To generate a collaboration between manager, suppliers and maintainers so that it drives the technical development of railway products, and especially turnouts, forward to achieve lower maintenance and life cycle costs as well as increased punctuality. The goal is to develop working methods facilitating innovation that are tailor-made for the railway sector.
Duration: 2012 – 2016

Key Performance Indicators for control and management of railway vehicles
Sponsor: Swedish Transport Administration
Researchers: Eirik Naana, Aadya Pandi, Ramin Karim & Philip Tretten
Objective: 1. To support LKAB in achieving its production targets through assessment of the maintenance process efficiently. 2. To develop & assess the maintenance process performance with appropriate metrics / ratios. 3. To provide integration of Power KPIs to meet the business needs through performance monitoring and development of a demonstrator to implement this key system through an eKMaintenance solution.
Duration: 2013 – 2017

Research implementation
Sponsor: JVT/CTU, Trollhattan
Researchers: Veronica Jagare
Objective: To contribute to a greater understanding of the challenges that the utilisation of research and development within operation and maintenance of the railway system offers, the factors affecting implementation and provide a knowledge-based decision support model, taking into account multiple stakeholders.
Duration: 2014 – 2019

On-going European Union (EU) Projects within the framwork of FP7

BGLC (Baltic Green Logistic Corridor)
Sponsors: Baltic Sea Region, The Bothanian Corridor
Researchers: Ulla Juntti & Aditya Pandi
Objective: The overall objective of BGLC is to increase the integration between the northern Scandinavia and Baltics, with its vast natural resources and increasing industrial production, with the industrial chain and test markets in the Baltic, Sea Region and central Europe.
Duration: 2011 – 2014

CETIA (Coastal Environment, Technology & Innovation in the Arctic)
Sponsors: EU, Kolidect & Länsstyrelsen Norrbotten
Researchers: Rupesh Kumar & Uday Kumar
Objective: There is a need for increased knowledge, education and training both to raise awareness and increase regional competence to manage commercial activities and manage the marine environment. In addition there is a need for increased innovation to monitor pollution and manage sensitive coastal environments.
Duration: 2011 – 2014

On-going European Union (EU) Projects within the framwork of FP7

OPTIRAIL
Sponsors: EU, FP7 (Seventh Framework Programme)
Researchers: Diego Galar, Roberto Villarejo & Uday Kumar
Objective: The main objective of the OPTIRAIL project is to develop a new tool, based on Fuzzy and Computational Intelligence techniques and validated through two case studies, that will enable the better cross-border coordination for decision making of railway infrastructure maintenance across Europe.
Duration: 2012 – 2015

SUSTRAIL (The sustainable freight railway)
Sponsors: EU, FP7 (Seventh Framework Programme)
Researchers: Matti Rantatalo, Mattias Asplund & Uday Kumar
Objective: The SUSTRAIL objective is to develop a novel decision support system for predictive maintenance, based on Fuzzy and Computational Intelligence techniques, that will enable the better cross-border coordination for decision making of railway infrastructure maintenance across Europe.
Duration: 2012 – 2015

On-going European Union (EU) Projects within the framwork of FP7

TREND (Test of Rolling Stock Electromagnetic Compatibility for cross-Domain Interoperability)
Sponsors: EU FP7 (Seventh Framework Programme)
Researchers: Diego Galar, Uday Kumar & Emilio Rodriguez
Objective: The main objective of this project is to design a test setup that enables the harmonisation of freight and passengers rolling stock approval tests for electromagnetic compatibility (EMC) focusing not only on interferences with broadcasting services but also on railway signalling systems.
Duration: 2011 – 2014

iMAIN - Intelligent maintenance
Sponsors: EU FP7 (Seventh Framework Programme)
Researchers: Ramin Karim, Philip Tretten & Uday Kumar
Objective: The objective is to develop a novel decision support system for predictive maintenance.
Duration: 2012-2015

SAFT Inspect: Ultrasonic synthetic Aperture Focusing Technique for Inspection of Railways Crossings (Frogs)
Sponsors: EU FP7 (Seventh Framework Programme)
Researchers: Matti Rantatalo, Johan Carlsson
Objective: The SAFT Inspect aims to develop an affordable and reliable ultrasonic inspection solution for sections of high manganese steel rail crossing points, which are used in the European railways. A non-destructive testing (NDT) inspection solution will be developed in the project to facilitate early defect detection of crack defects at safety critical locations.
Duration: 2012 – 2014

MAINLINE
Sponsors: EU FP7 (Seventh Framework Programme)
Researchers: Lennart Eigen
Objective: The main objectives of the MAINLINE are to develop new technologies to extend the life of elderly railway infrastructure across Europe, improve degradation & structural models to develop more realistic life cycle cost & safety models and to investigate monitoring techniques to complement or replace existing examination methods.
Duration: 2011 – 2014
Publications

Journals


Uday Kumar, invited speech. Senaste forskningens inram (årskonferens), at Transport Committee, Swedish Parliament, December 11, 2014, Stockholm

Diego Galar, EAM Conference – Enterprise Asset Management Europe, 11-14 November 2014, Copenhagen

Diego Galar, Advanced measurement tools in technical diagnostics for systems’ reliability and safety, June 26 – 27 2014, Uppsala, Sweden


Diego Galar, La contratación basada en el desempeño: La nueva forma de hacer negocios en el mantenimiento. Congreso Internacional de Ingeniería en Mantenimiento, 18-19 June 2014, Córdoba, Ría

Diego Galar, delivered keynote speech at Maintenance Performance Measurement and Management Conference, 4 – 5 September 2014, Como, Portugal

Diego Galar, Maintenance within Asset Management. Fra Asset Management til Maintenance within Asset Management, 23 – 24. september 2014, Oslo

Diego Galar gave invited speech at Spanish reliability congress, 3-4 december, 2014, San Sebastián

Allena Ahmed, invited key note. Title: Reliability assurance through maintenance. The 3rd International Conference on Reliability Engineering PEG 2014- Feb, 4-5, 2014, Amirkabir University of Technology, Tehran, Iran

Per Olaf Larsen Kvåle, Hur transportera vi en oss fram till 2040? Anlaggsdagar, 18 march 2014, Stockholm, Sweden

Per Olaf Larsen Kvåle, 26th ELS/EAM Annual General Meeting, 26th –26th April 2014, Dubrovnik, Croatia

Per Olaf Larsen Kvåle, gave keynote speech of COMADEM 2014, 16-18 September, Brisbane, Australia

Per Olaf Larsen Kvåle, gave keynote speech at Asset Management and Maintenance Conference16 September 2014 - 17 September 2014, Australia, Queensland, Brisbane

Per Olaf Larsen Kvåle, gave keynote speech at ELSWG, 17th - 18th November 2014, Amsterdam, Holland

Keynote/Invited speech


Delghandi, SH, Sayadi, AR & Hesoein, A. (2014). ‘Reliability analysis of the loading system of hydraulic excavator’ Artikeln har presenterats vid International Conference on Reliability Engineering, Tehran, Iran, 04/02/14 - 05/02/14.


Delghandi, SH, Sayadi, AR & Hosein, A. (2014). ‘Reliability analysis of the loading system of hydraulic excavator’ Artikeln har presenterats vid International Conference on Reliability Engineering, Tehran, Iran, 04/02/14 - 05/02/14.


