Application

2015-03-31

2015-05250	Lin, Jing (Janet)	NT-14

Information about applicant

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Doctorial degree: 2008-04-30

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Administrating organisation: Luleå Tekniska Universitet

Project site: Avdelningen för drift, underhåll och akustik

Information about application

Call name: Forskningsbidrag Stora utlysningen 2015 (Naturvetenskap och teknikvetenskap)

Type of grant: Projektbidrag

Focus: Unga forskare

Subject area:

Project title (english): @LEARNING: Assets Collaborative Learning

Project start: 2016-01-01

Project end: 2019-12-31

Review panel applied for: NT-14, NT-2, NT-1

Classification code: 21199. Övrig annan teknik

Keywords: Asset Efficiency Optimization, reliability centered dependability management, collaborative maintenance techniques, complex system, Industry 4.0

Funds applied for

Year:	2016	2017	2018	2019
Amount:	1,000,000	1,000,000	1,000,000	1,200,000

Descriptive data

Project info

Project title (Swedish)*

@LEARNING: Gemensamt Lärande av Industriella Utrustningar

Project title (English)*

@LEARNING: Assets Collaborative Learning

Abstract (English)*

It is not only humans who can learn. Now, in Industry 4.0 (the fourth industrial revolution), complex systems already "talk" (incl. communication and cooperation) to each other (facilitated by Internet of Things (IOT), Cyber-physical systems, etc.). They will soon "learn" from each other and grow in the same fashion as humans.
The purpose of this project is to develop novel Asset Efficiency Optimization (AEO) strategies for complex systems, through which they can have "collaborative learning" capabilities that will promote sustainable and cost-effective asset efficiency optimization in product and process engineering.
Specific objectives include the creation of an original Reliability Centered Dependability Management (RCDM) philosophy, development of innovative Collaborative Maintenance Techniques (CMT), and a demonstrator to visualize and verify the developed AEO strategies.
To create the original RCDM philosophy, an integrated system dependability management process will be adopted. In this process, technical perspectives (incl. hardware and software), human and organizational systems, and environmental influences will be sufficiently considered. To develop the innovative CMT, advanced knowledge-driven approaches (incl. causal inference from Bayesian statistics to big data analytics), new Information and Communication Technologies (ICT), and knowledge integration and updating will be applied. The proposed RCDM and CMT will also deal with Multi-objective Optimization Problems (MOP) and be illustrated by a developed demonstrator, named @LEARNING.
This project is significant in terms of dealing with increasing system complexity. It addresses knowledge gaps that with originate in AEO sector, and influence ability to meet challenges specific to Industry 4.0. By making complex systems to learn collaboratively in the same fashion as humans, this project will change assumptions in current research that "all complex systems are the same if they have the same physical components; and that their behavior can be predicted or diagnosed". The proposed ideas on RCDM and developed CMT will create novel point of view to deal with risk factors or explanatory variables which are not always known or measurable in a complex system. These will also enrich related academic topics including big data analytics, knowledge integration and updating, and MOP.
This project will include seven work packages and each contains several research tasks. The work will start in January 2016 and end in December 2019. A PhD-student will be recruited and trained in the field of AEO.

Popular scientific description (Swedish)*

Mina egna funderingar kring ett barn kan likvärdigt tillämpas på forskning inom optimering av tillgångseffektivitet (AEO) för industriella utrustningar.
Sedan vårt första barn Ian föddes 2014, har vi, förutom att regelbundet besöka barnavårdscentralen för att mäta barnets vikt, längd och huvudlängd, sökt kunskap och erfarenhet från olika källor för att minska sannolikheten för att en ”olycka” ska inträffa. Även om vi litar på källorna, så har vi inte följt någon källa till 100 procent. Varje spädbarn är unikt och därför kan ingen perfekt modell förutse eller ställa diagnos på vårt barns beteende. Dock skulle vi lita mer på rapporter som grundar sig på asiatiska barn, särskilt kinesiska barn, eftersom vårt kinesiska ursprung innebär att Ian kommer att ha mer gemensamt med dem som sina ”närmaste grannar”.
Vänner och bekanta försöker nu övertala oss att skaffa ett barn till. Vi är inte övertygade om detta eftersom vi känner oss helt slut av att ta hand om Ian. Men vännerna säger att allt går lättare med det andra barnet: i takt med att barnet växer upp kan barnen prata med varandra och lära sig saker och ting tillsammans. Ju mognare barnen är, desto bättre är deras inlärningsförmåga.
Reflektionerna ovan kan tillämpas på optimering av tillgångseffektivitet genom två frågeställningar: Varför tror jag inte att det finns en perfekt modell för Ian? 2) Varför anser föräldrar att det blir enklare att ta hand om det andra eller tredje barnet, i förhållande till det första.
Både barn och komplexa system är unika trots att de har ”grannar” med likheter. Vi kan därför inte förvänta oss att förutse eller ställa en diagnos för enskilda system baserat på kunskap om andra system. Forskning för att reducera osäkerheter i komplexa system bygger antaganden om att identifiera systemens likheter och att systemens beteende kan förutses om de gemensamma variablerna är tillräckligt kända och exakt beskrivna. Med vad är ”tillräckligt” och ”exakt”. Man kan därför hävda att vi bör frångå antagandena genom att medge att varje system är unikt, trots dess ”närmaste grannar”.
För barn är det dessutom så att ju mognare de är desto bättre blir deras inlärningsförmåga, de lär sig från sina syskon och andra barn. Situationen är annorlunda när vi pratar om system inom produkt- och processteknik. Tack vare ny teknik kan system ”prata” med andra system. Men kan de dra ”lärdom” från varandra? Komplexa system kan, enligt min mening, ”gemensamt dra lärdom” av varandra och växa och mogna på samma sätt som människor.
Med andra ord kan inte bara individuella maskiner lära sig på egen hand med hjälp av datorvetenskap (så kallad maskininlärning), utan komplexa system (till och med organisationer) kan ha sådana förmågor. För att utveckla systemens förmåga att ”prata” med varandra och verkligen ”lära sig” av varandra, kommer projektet att beakta skillnader och likheter mellan komplexa system för att skapa ett nytt ramverk för optimering av tillgångseffektivitet. Genom att använda sig av ”rekommendationer” från ”närliggande grannar”, kommer en demonstrator att utvecklas som kallas @LEARNING som ska sluta processen för gemensamt lärande.
Projektet kommer att ifrågasätta antaganden inom aktuell forskning och idéer som utvecklas, kommer att ge upphov till nya forskningsområden för stordataanalyser, kunskapsintegrering och uppdatering, samt kompromisser mellan två eller flera motstridig, som för närvarande är mycket populära ämnen. Genom att tillämpa ny informations och kommunikationsteknik, kommer projektet att styra forskare i riktning mot samarbete. Projektet kommer också att bidra till att möta de utmaningar som är specifika för den fjärde industriella revolutionen, vilket representerar ett kunskapsområde som har sitt ursprung i optimering av tillgångseffektivitet.
Arbete med de nya utmaningar som projektet bemöter måste pågå parallellt med nuvarande arbetssätt.

Project period

Number of project years*

4

Calculated project time*

2016-01-01 - 2019-12-31

Deductible time

Deductible time

	Cause	Months
1	Parental leave	4
	Total	4

Career age: 79

Career age is a description of the time from your first doctoral degree until the last day of the call. Your career age change if you have deductible time. Your career age is shown in months. For some calls there are restrictions in the career age.

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes* 2. Teknik > 211. Annan teknik > 21199. Övrig annan teknik

Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

Asset Efficiency Optimization

Keyword 2*

reliability centered dependability management

Keyword 3*

collaborative maintenance techniques

Keyword 4

complex system

Keyword 5

Industry 4.0

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

This project does not raise any ethical issues.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

@LEARNING:

Assets Collaborative Learning

1 Purpose and aims

It is not only humans who can learn. Now, in Industry 4.0 (the fourth industrial revolution), complex systems already "talk" (incl. communication and cooperation) to each other (facilitated by Internet of Things (IOT), Cyber-physical systems, etc.). They will soon "learn" from each other and grow in the same fashion as humans.

The purpose of this project is to develop novel Asset Efficiency Optimization (AEO) strategies for complex systems, through which they can have "collaborative learning" capabilities that will promote sustainable and cost-effective asset efficiency optimization in product and process engineering.

Specific objectives include:

- An original philosophy of Reliability Centered Dependability Management (RCDM);
- Innovative Collaborative Maintenance Techniques (CMT);
- Demonstrator to visualize and verify the developed AEO strategies.

2 Survey of the field

Asset Efficiency Optimization (AEO) strategies have been challenged in Industry 4.0. Asset excellence and effective maintenance strategies can influence the productivity, profitability, and competitiveness of a manufacturing process. In Industry 4.0, the fourth industrial revolution, as promoted by German government in 2011, globalization and consolidation are cited as playing an instrumental role in changes in maintenance standards and approaches, and the use of technology to increase efficiency and cost-effectiveness. Globalization and consolidation, and changes in technology are challenging asset management and maintenance professionals to be more efficient in what they do at various levels [1] [2]. Asset Efficiency Optimization (AEO) is a service or a process designed to achieve maximum efficiency and effectiveness from asset and maintenance management strategies[1]. *Due to increasing complexity of assets and organization, unfortunately, no current AEO strategies fit all requirements and new challenges keep appearing.* Although preventive, predictive and proactive maintenance strategies have all been emphasized for both hardware (HW) and support services (SS) in product and process engineering [3] [4]. Most companies, i.e. about 81% in Sweden, use accumulated knowledge and experience as a main approach in the selection of maintenance strategies [5]. Of these, about 31% use a method based on modeling the time to failure and optimization, 10% use failure mode effect and criticality analysis (FMECA) and decision trees, and only 2% use multiple criterion decision making (MCDM). About 30% use a combination of at least two methods. In Industry 4.0, improved automation technology is required, including self-optimization, self-configuration, self-diagnosis, cognition and intelligent support of engineers in increasingly complex work. Obviously, *these current situations in AEO strategies cannot fulfill the challenges we meet in the era of Industry 4.0*.

AEO strategies for complex systems need to be developed in a holistic manner. Once decisions about asset management and maintenance strategies have been made, it is important to review the effectiveness of maintenance strategies regularly and make ongoing improvements [6]. Studies of decision support for AEO strategies generally focus on certain specified areas, depending on the classification. *Related definitions are inconsistent across systems and networks, and studies in the various areas have evolved nearly independently*. Take dependability for example, in the computing research community (from the software perspective), dependability consists of availability, confidentiality, integrity, performance, reliability, survivability, safety and maintainability [7].

[1] http://www.skf.com/group/services/asset-management-services/asset-efficiency-optimisation/index.html

While in the process industry for infrastructure [8] [9], dependability includes safety and availability, thus requiring consideration of reliability, maintainability, and supportability. A more popular area of study is RAMS (Reliability, Availability, Maintainability and Safety) or RAMS4 which incorporates supportability, sustainability, and security. Furthermore, asset management systems are increasingly complex and now include both hardware and software. *It means studies on system dependability need to be merged in a more generic way*. In addition to the increasingly complicated technical dimensions, production systems are beginning to consider the effect of human, organizational, and environmental factors [10] [11]. *To date, however, limited research has been conducted on system dependability in a holistic manner.*

Innovative Collaborative Maintenance Techniques (CMT) need to be developed to assist complex system learning collaboratively. Thanks to the new Internet of Things (IOT), Cyber-physical systems, and FRID technologies, in Industry 4.0, assets can "talk" (incl. communication and cooperation) to other assets. *Assets (incl. complex systems) can also "learn collaboratively" from each other and grow in the same fashion as humans.* In other words, not only can individual machines learn by themselves with the help of computer science (i.e., machine learning) but complex systems can embrace such capabilities. However, to foster their ability to "talk" to each other and really "learn" from each other, "collaborative maintenance" technologies (CMT) [12] [13] [14], a relatively new concept, requires further study. One hidden assumption of current research on reducing the uncertainties of parameters' estimations of a complex system is that some complex systems are the same if they have the same physical components; their behavior can be predicted, or diagnosed if the covariates are sufficiently recognized and exactly described. However, the difficulty is the "sufficient" and "exact" description. *Arguably, we should break these assumptions in developing innovative CMT by admitting each system is unique, despite its "neighbors" which may have similar behavior like the objective system.* The heterogeneities among systems have been described as different frailties[2]. Through that, a novel point of view to deal with risk factors or explanatory variables which are not always known or measurable in complex system has been created [15] [16].

Integrated, knowledge-driven approach needs to be developed to support AEO by considering different types of data no matter if it is big or small. To improve the decision-making process in AEO, data from various sources (e.g. product, production, maintenance, and business) must be collected, integrated, fused, and analyzed, to transform them from information into knowledge. Given the quickly developing areas of Information and Communication Technologies (ICT), *new knowledge-driven (or data-driven) approaches in computational sciences and applied mathematics must be developed to support AEO strategies, to predict, diagnose or make a prognosis of a complex system's behavior*. Recently, increasing attention is paid to big data analytics to extract information, knowledge and wisdom from big data [15]. For instance, in 2015, European Research council (ERC) announced two research grants in this area, one for ERC Consolidator Grants and another for ERC Starting Grants[3]. This emerging phenomenon reflects the ever-increasing significance of data not only in terms of their growing volume, variety and velocity (three attributes of big data), but also in value, veracity, and complexity. *In the AEO field, big data have huge potential to enable more sophisticated knowledge-driven decision making and facilitate new ways to organize, learn and innovate.* Although big data are starting to "meet" reliability [16] (part of AEO content) with ongoing visible and invisible issues, the research gaps in AEO remain large[4]. As

[2] As study of locomotive wheel-sets revealed *similarities* and *differences* among them (complex systems). Our findings have been published in journals from Web of Science, including: Journal of Quality and Reliability Engineering International (2014), Journal of Eksploatacja i Niezawodnosc - Maintenance and Reliability, Journal of Reliability Engineering & System Safety (2015), Journal of Rail and Rapid Transit (2015) and two research reports published by LTU

[3] http://erc.europa.eu/

[4] I am assisting a doctoral student in big data analytics; some interesting results addressing "high dimensionality" and "high velocity" challenges of maintenance data stream have been submitted to well-respected journals.

pointed by Professor Judea Pearl, winner of the 2011 A.M. Turing Award, that "big data must go to causal"[5]. He also pointed out many data scientists remain unconcerned about the critical distinction between statistical and causal inference. Although some researchers suggest "big data" represent the "next big thing in innovation", "the fourth paradigm of science", or "the next frontier for innovation, competition, and productivity", however, small data (or incomplete, censored/truncated, or no data) still exist and challenge current asset management [17] [18]. *Meanwhile, no matter whether data are "big" or "small", some "old problems (incl. uncertainties on the parameter estimation, complexity and large-scale system, dependences between events)" must be studied further* [19].

Multi-objective Optimization Problems (MOP) need to be integrated in AEO strategies. Considering the harsher limitations imposed on decision makers today (incl. resources, cost, humanity, environmental influences), integrated AEO strategies (considering RCDM and CMT) must be studied together with lifecycle cost (LCC). However, a survey of Multi-objective Optimization Problems (MOP) models for related topics shows: 1) few MOP algorithms and models have been studied in RCDM or CMT; 2) few of them can sufficiently consider characteristics simultaneously from RCDM, CMT, and LCC. Besides traditional technologies, *Bayesian Optimization Algorithm (BOA) and Bayesian Belief Networks (BNN) can deal will MOP in more flexible way* since their capabilities to consider prior information. These technologies will be further developed and used to validate the AEO strategies of the proposed project.

3 Project description

3.1 Project Summary

Knowledge Gaps show current research has not yet dealt with the demands of increasing system complexity; while globalization and consolidation, and changes in technology are challenging, asset optimization and maintenance professionals have to be more efficient in what they do at various levels.

We make a **hypothesis** that, it is not only humans who can learn. Individual machines have already learnt by themselves and talked with each other with the help of new ICT. In our view, complex systems can "learn collaboratively" from each other and grow in the same fashion as humans. By showing how they can embrace such capabilities, our research will promote sustainable and cost-effective asset efficiency optimization in product and process engineering.

To foster their ability to "talk" to each other and really "learn" from each other, in this project, we will develop novel Asset Efficiency Optimization (AEO) strategies by replacing current management philosophy with a new one, Reliability Centered Dependability Management (RCDM), and developing "collaborative maintenance" technologies, a relatively new concept. To create the original RCDM philosophy, an integrated system dependability management process will be adopted. In this process, technical perspectives (incl. hardware, software), human and organizational systems, and environmental influences will be sufficiently considered. To develop the innovative CMT, new Information and Communication Technologies (ICT), advanced knowledge driven approaches (incl. causal inference from Bayesian statistics to big data analytics), and knowledge integration and updating will be applied. The proposed RCDM and CMT will also deal with Multi-objective Optimization Problems (MOP) and be illustrated by a developed demonstrator, named @LEARNING.

3.2 Project Outline

In this subsection, the goals and content of the project are outlined. A suggested structure of this project is shown in Fig. 1, where "WP" represents Work package. Detailed relationships among those Work packages are also presented in the structure and content of the project.

[5] http://www.bayesia.us/blog/why-big-data-must-go-causal

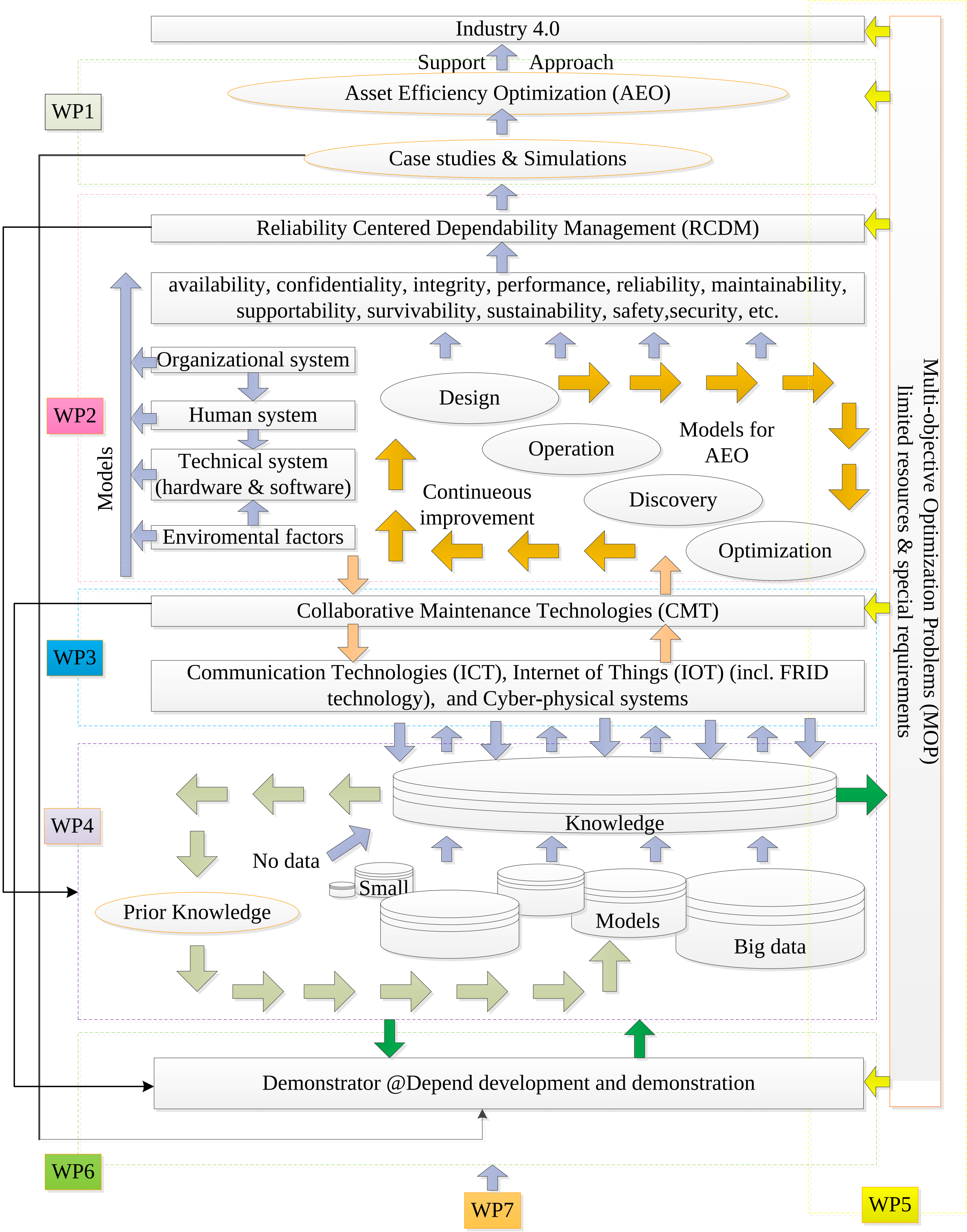

Fig.1 suggested structure of @LEARNING

Work package 1: Asset Efficiency Optimization (AEO) framework

Goal: The goal is to define premises and requirements used throughout the project and to reconstruct the AEO framework (incl. procedures, tools and data).

Content: To construct the new AEO framework, we will redefine inconsistent definitions (related to dependability management) across system and networks in AEO sector. We will also clarify requirements for the @LEARNING subsystems. After completing other work packages, we will implement case studies and simulations in the railway industry. The results will be used to test the proposed framework and make optimization. Tasks in Work package 1 include:

- Task 1.1 Analysis of existing procedures and factors for AEO and new construction of AEO
- Task 1.2 Requirements for the @LEARNING subsystems
- Task 1.3 Case studies
- Task 1.4 Framework evaluation and optimization

Work package 2: Reliability Centered Dependability Management (RCDM) philosophy

Goal: The goal is to create an original Reliability Centered Dependability Management (RCDM) philosophy.

Content: We will adopt an integrated system dependability management process, in which technical perspectives (incl. hardware, software), human and organizational systems, and environmental influences will be sufficiently considered. The original RCDM philosophy will also adopt sustainable improvement process in which four stages will be considered: Design, Operation, Discovery, and Optimization. Tasks in this Work package include:

- Task 2.1 Definition and consolidation of RCDM
- Task 2.2 Integration of technical, human and organizational, environmental factors
- Task 2.3 Development of context in a sustainable dependability management framework

Work package 3: Collaborative Maintenance Technologies (CMT)

Goal: In this work package, the innovative Collaborative Maintenance Techniques (CMT) will be developed based on new ICT.

Content: We will perform new ICT including Internet of Things (IOT) (incl. FRID technology), and Cyber-physical systems to support development of innovative CMT. The requirements analysis from Work package 1 and the original RCDM philosophy proposed in Work package 2 will be utilized. Results from Work package 3 will be used to support the integrated knowledge-driven approach in Work package 4.The results are also important for @LEARNING development in Work package 6. Tasks in Work package 3 include:

- Task 3.1 Development of CMT
- Task 3.2 Development of system/organization learning structure
- Task 3.3 Design of procedure, algorithms and models for implementation of CMT

Work package 4: Integrated knowledge-driven approach

Goal: The goal is to create a generic knowledge-driven approach considering “small” and “big data” to support RCDM (developed in Work package 2) and CMT (developed in Work package 3).

Content: We will explore how to integrate knowledge achieved by different sources, different models and how to continuously update the (prior) knowledge with new information and new data. We will perform knowledge driven approaches (incl. causal inference from Bayesian statistics to big data analytics). Those approaches should not only deal with “small data” (small sample data for analysis, incomplete data set with censored or truncated data) but also meet challenges raised by “big data” (data not only in terms of their growing volume, variety and velocity (three attributes of big data), but also in value, veracity, and complexity). Tasks in this Work package include:

- Task 4.1 Data management
- Task 4.2 Development of knowledge-driven approaches considering different types of data
- Task 4.3 Development of models for knowledge integration
- Task 4.4 Development of models for knowledge updating

Work package 5: Multi-objective Optimization Problems (MOP)

Goal: The goal is to study how to make AEO strategies considering limited resources and capabilities or other special requirements.

Content: Bayesian Optimization Algorithm (BOA) and Bayesian Belief Networks (BNN) will be utilized to support AEO strategies considering limited resources and capabilities (incl. cost, human labor, time, spare parts, etc.) or other special requirements (e.g., specified safety threshold, etc.). The strategies will also be studied together with lifecycle cost (LCC). The studied MOP should sufficiently consider characteristics both from proposed RCDM and CMT. Tasks in this Work package include:

- Task 5.1 Mathematical modeling and algorithm design based on BNN and LCC
- Task 5.2 Case studies

Work package 6: Demonstrator (@LEARNING) development and demonstration

Goal: The goal is to develop demonstrator @LEARNING.

Content: We will develop the demonstrator @LEARNING using ASP.net to demonstrate the protocol AEO strategies. Tasks include:

- Task 6.1 @LEARNING development and documenting
- Task 6.2 @LEARNING testing and evaluation by demonstrating of the protocol
- Task 6.3 @LEARNING optimization

Work package 7: Project Management

Goal: The goal of this Work package is to implement efficient management for the full project.

Content: We will implement administrative, legal, financial, and risk management. Tasks in this Work package include:

- Task 7.1 Project coordination
- Task 7.2 Quality assurance and control
- Task 7.3 Risk management
- Task 7.4 Financial management
- Task 7.5 Establishment and coordination of the external advisory board

3.3 Working Plan

The activity plan, time frame, milestones are summarized in Table 1 below. In the table, “WP” represents Work Packages, “T” represents Tasks, “D” represents Deliverables, and “M” represents Milestones. The work is estimated to start in January 2016 and be finalized in December 2019. Every three months of the project time are numbered Q1-Q4 in columns. Estimated time frame for the different activities, deliverables and milestones is marked with “X” in the table.

Table 1 Working plan

Work Packages (WP) and Tasks (T)		2016				2017				2018				2019			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
WP1	T1.1	X	X														
	T1.2	X	X														
	T1.3												X	X	X		
	T1.4												X	X	X		
WP2	T2.1		X	X													
	T2.2		X	X													
	T2.3			X	X												
WP3	T3.1							X	X	X							
	T3.2								X	X	X	X					
	T3.3								X	X	X	X	X	X	X		
WP4	T4.1					X	X	X	X	X	X	X	X				
	T4.2					X	X	X	X	X	X	X	X				
	T4.3									X	X						
	T4.4											X	X				
WP5	T5.1									X	X	X	X				
	T5.2									X	X	X	X				
WP6	T6.1													X	X	X	X

	T6.2													X	X	X	X
	T6.3													X	X	X	X
WP7	T7.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	T7.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	T7.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	T7.4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	T7.5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Deliverables (D)																	
D1.1	Requirements analysis		X														
D1.2	Case studies														X		
D2.1	Report on RCDM				X												
D2.2	Paper on RCDM				X												
D3.1	Report on CMT														X		
D3.2	Paper on CMT										X						
D4.1	Report on knowledge-driven												X				
D4.2	Paper on knowledge-driven							X									
D5.1	Report on MOP												X				
D5.2	Paper on MOP												X				
D6.1	Demonstrator @LEARNING																X
D6.2	@LEARNING results report																X
Milestones (M)																	
M1	Submissions of papers		X		X			X			X		X		X		
M2	Publication of reports				X								X		X		X
M3	Mid-evaluation								X								
M4	Completion of demonstrator																X
M5	Result dissemination				X				X				X				X
M6	Licentiate thesis								X								
M7	PhD dissertations																X
M8	Success of @DEPEEND																X

3.4 Project organization

Jing (Janet) Lin: Associate Professor and Docent at LTU. Janet has been involved in research in Asset Management, Reliability and Management Engineering since 2003. After she got her PhD in Management Science in China, she worked several years for SKF Co., Ltd as an Asset Management Consultant for. After her move to LTU she has made contributions to research topics in reliability, maintainability, and asset management in which she has published about 50 scientific publications. Janet has obtained PMP® in 2010 from PMI (Project Management Institute) Global Operations Center, USA. In this project she will serve as scientific coordinator and main supervisor for the PhD-student to be recruited. Janet will take an active part in all work packages. Her involvement will be 60% of full time.

PhD-student: To be recruited. Suitable background is Operation and Maintenance Engineering or similar with a profile in management science, control engineering, computer engineering, system theory and statistics. The student is expected to work 80% in this project and the achievements will be followed using an individual study plan (ISP).

Expert reference group will be connected to the project in order to support different work packages:

- **Uday Kumar:** Chair Professor in Operation and Maintenance Engineering at LTU. Uday has been involved in research in Operation and Maintenance Engineering since 1980s, in which he has published more than 300 scientific publications. In particular he has received Nordea Scientific prize in Sweden in 2014 for his contributions to internationally successful research. In this project, he will lead the expert reference group, promote national and international cooperation, assist project dissemination, quality assurance and risk management.

- **Aditya Parida:** Professor in Asset Management at LTU. Aditya is most well-known for his contributions to Asset Management. In this project, he will be able to help as expert in Work package 1 and Work package 2.
- **Per-Olof Larsson-Kråki:** Adjunct Professor in Maintenance Engineering at LTU and Trafikverket (Swedish Transport Administration). In this project, he will help as expert in Work package 2 and Work package 5. In particular, Per-O will guide the case study which will be used to test the AEO strategies.
- **Huiming Zhu:** Professor in Business Management and Statistics at Hunan University in China. Professor Zhu has collaborated with Janet since 2003 in reliability and management science. He is most well-known in Statistics. In this project, he will help in Work package 5.
- **Ramin Karim:** Associate Professor and Docent in e-maintenance at LTU. Ramin is most well-known in ICT applications in Asset Management. He has also leaded the set-up of e-maintenance lab at LTU. In this project, he will help as expert in Work package 3 and 4.

The whole working group will meet at least once per year and communicate more frequently as needed through other media (email and telephone).

3.5 Expected deliverables and dissemination

- The project results will be disseminated to the scientific community through at least four peer-reviewed publications in international journals following the Open Access regulations, participation in scientific conferences (e.g. The 63th Annual Reliability and Maintainability Symposium (RAMS® 2017)), according to the following approximate scheme: WP2 (at least 1), WP3 (at least 1), WP4 (at least 1), WP5 (at least 1).
- Reports and a final project report will be delivered according to the schedule.
- The project results will be included in the lecture material for the course "RAMS Engineering", "Reliability in Maintenance", and "Asset Management" given at LTU.
- At least one popular science seminar will be given through "Vetenskapenshus" at LTU or international webinar, e.g. ASQ (American Society for Quality).
- Information for industry and other stakeholders and decision makers will be communicated through workshops and presentations during the project meetings and through LTU's website.
- Existing co-operation within national and international networks will be used to disseminate project findings.
- The results of the research can be disseminated to potential end-users in the process industry, including (but not limited to): Metallurgy, Mining, Petroleum & Chemical, Paper & Wood, Power, Automotive, Food & Beverage, and Railway.

4 Significance

Both Assets and organizations are becoming more and more complex. The importance of dealing with increasing system complexity in AEO sector is well recognized. At the same time, Industry 4.0 challenges asset optimization and maintenance professionals to be more efficient in what they do at various levels. <u>This project represents a knowledge area that with origins in AEO sector. We will be first to explore studies on Assets Collaborative Learning.</u> It can be considered a facilitator of the ability to meet challenges specific to Industry 4.0. By making complex systems to learn collaboratively in the same fashion as humans, this project will change assumptions in current research that "all complex systems are the same if they have the same physical components; and that their behavior can be predicted or diagnosed". The proposed ideas on RCDM and developed CMT will create novel point of view to deal with risk factors or explanatory variables which are not always known or measurable in a complex system. These will enrich related academic research topics including big data analytics, knowledge integration and updating, and MOP, currently very popular topics. The constellation of research team ensures realization, that the results will form a basis for future research and development in management science, control engineering, computer engineering and system theory.

5 Preliminary results

The *similarities* and *differences* existing among complex systems have been revealed in the studies of locomotives [16], [20-22], which are important findings for this project. In these studies, we found the wheel-sets will "learn" how to predict, diagnose, or make a prognosis of their behavior from their "neighbors" according to their operating environment (e.g., climate, topography, track geometry), configuration of the suspension, status of the bogies and spring systems, operating speeds and applied loads, as well as human influences (drivers' operations, maintenance policies, lathe operators etc.). In above studies, the *heterogeneities* (differences) among systems have been described as gamma shared frailties [16, 22].

A simple *sustainable improvement process* for AEO has been suggested and presented in [6]. The proposed process for AEO which is named as "House of Maintenance Management (HOMM)" will be developed further in Work package 2 as four stages: Design, Operation, Discovery, and Optimization, to fill the requirements for new RCDM philosophy.

In the area of knowledge-driven approaches, *Bayesian statistics* have been applied in many cases, with findings published as both journal and conference papers[6]; in *Big Data Analytics*, faulty detection topics using high-dimensional data have been considered, with findings submitted to journals in 2015. Above achievements and related research experience will supply foundations in completing Work package 4.

6 Independent line of research

This project will help to build a new research team for future development in the area. I am currently Associate Professor (and Docent) at LTU in the Division of operation and maintenance; the project will help me advance academically in my research field in AEO through: publishing research papers and reports (without supervisor), developing collaboration with senior researchers both nationally and internationally, participating and making presentation in scientific conferences, holding popular science seminars and international webinars.

In the Division of operation and maintenance at LTU, reliability, dependability, AEO, e-maintenance and related topics are the current research focus. Results from this project on RCDM, knowledge-driven approaches and MOP models will complement our AEO and RAMS (Reliability, Availability, Maintainability, and Safety) related projects, supplying methodologies for studying them at a system level, not just at a component level. The project's development of new CMTs and the corresponding demonstrator will support our e-maintenance projects.

7 Form of employment

Besides PI, this project is planning to employ one PhD-student.

Table.2 form of employment

Employment	percent	Duration	
		From	to
PI	60%	2016-01-01	2019-12-31
PhD-student	80%	2016-01-01	2019-12-31

Reference

[1] J. D. Campbell, A. K. Jardine and J. McGlynn, Asset Management Excellence:Optimizing Equipment Life-Cycle Decisions (2nd Edition), Boca Raton: Taylor & Francis Group,LLC, 2011.

[2] I. Alsyouf, "The role of maintenance in improving companies' productivity and profitability," *International Journal of Production Economics*, vol. 105, pp. 70-78, 2007.

[3] M. Löfstrand, S. Reed, M. Karlberg, J. Andrews, L. Karlsson and S. Dunnett, "Modelling and simulation of functional product system availability and support costs," *International Journal of Product Development*, vol. 16, nr 3/4, pp. 304-325, 2012.

[6] Details can be found in publication list.

[4] T. Markeset och U. Kumar, ”Dimensioning of Product Support:Issues,Challenges,and Opportunities,” i *Annual Reliability and Maintainability Symposium* , Los Angeles, USA, 2004.

[5] I. Alsyouf, ”Cost Effective Maintenance for Competitive Advantages,” Intellecta Docusys, Göteborg, Sweden, 2004.

[6] J. Lin, B. Ghodrati and U. Kumar, ” House of Maintenance Management in Mining Industry” i *IEEE International Conference on Quality and Reliability*, Bangkok, Tailand, 2011.

[7] K. S. Trivedi, D. S. Kim, A. Roy and D. Medhi, ”Dependability and Security Models,” i *7th International Workshop on the Design of Reliable Communication Networks*, Washington, DC, 2009.

[8] *EN 50126*, European Standard, 1999.

[9] J. Barabady, *Production Assurance: Concept, Implementation and Improvement,* Luleå, Sweden: Luleå University of Technology, 2007.

[10] M. C. Kim and P. H. Seong, ”A computational method for probabilistic safety assessment of I&C systems and human operators in nuclear power plants,” *Reliability Engineering and System Safety,* vol. 91, nr 5, pp. 580-593, 2006.

[11] P. Trucco, E. Cagno, F. Ruggeri and O. Grande, ”Bayesian Belief Network modelling of organisational factors in risk analysis: A case study in maritime transportation,” *Reliability Engineering and System Safety*, vol. 93, nr 6, pp. 845-856, 2008.

[12] J. Wang, P. W. Tse, L. He and R. W. Yeung, ”Remote sensing, diagnosis and collaborative maintenance with Web-enabled virtual instruments and mini-servers,” *International Journal of Advanced Manufaturing Technology,* vol. 24, pp. 764-772, 2004.

[13] K. Jenab and S. Zolfaghari, ”A virtual collaborative maintenance architecture for manufacturing enterprises,” *Journal of Intelligent Manufacturing,* vol. 19, pp. 763-771, 2008.

[14] M. Ferrario and B. Smyth, ”Distributing Case-Base Maintenance: The Collaborative Maintenance Approach,” *Computational Intelligence,* vol. 17, nr 2, pp. 315-330, 2001.

[15] J. Lin, M. Asplund and A. Parida, ”Reliability Analysis for Degradation of Locomotive Wheels using Parametric Bayesian Approach,” *Journal of Quality and Reliability Engineering International*, vol. 30, nr 5, pp. 657-667, 2014.

[16] J. Lin, P. Julio and M. Asplund, ”Reliability Analysis for Preventive Maintenance based on Classical and Bayesian Semi-parametric Degradation Approaches using Locomotive Wheel-sets as a Case Study,” *Journal of Reliability Engineering and System Safety,* nr 134, pp. 143-156, 2014.

[17] P. Russom, ”Big Data Analytics,” The Data Warehousing Institute (TDWI), Renton, WA, 2011.

[18] W. Q. Meeker och Y. Hong, ”Reliability meets big data:Opportunities and challenges,” *Quality Engineering,* vol. 26, pp. 102-116, 2014.

[19] E. Zio, ”Reliability engineering:Old problems and new challenges,” Reliability Engineering and System Safety, nr 94, pp. 125-141, 2009.

[20] J. Lin. *Data Analysis of Heavy Haul Locomotive Wheel-sets’ Running Surface Wear at Malmbanan.* Research Report. Published by: Luleå University of Technology. 2014, April

[21] J. Lin. *Using Integrated Reliability Analysis to Optimise Maintenance Strategies – A Bayesian Integrated Reliability Analysis of Locomotive Wheels.* ResearchReport. Published by: Luleå University of Technology. 2013, May

[22] J. Lin, M. Asplund. Bayesian Semi-parametric Analysis for Locomotive Wheel Degradation using Gamma Frailties. Institution of Mechanical Engineers. Proceedings. Part F: *Journal of Rail and Rapid Transit.* 2015, 229 (3):237-247

Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project*

	Role in the project	Name	Percent of full time
1	Applicant	Jing (Janet) Lin	60
2	PhD Student	PhD student	80

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Applicant	Jing (Janet) Lin	28	429,823	434,923	430,031	519,840	1,814,617
2	PhD Student	PhD student	37	195,087	197,402	195,181	235,944	823,614
	Total			624,910	632,325	625,212	755,784	2,638,231

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

	Type of premises	2016	2017	2018	2019	Total
1	Office rent	49,993	50,586	50,017	60,463	211,059
	Total	49,993	50,586	50,017	60,463	211,059

Running Costs

	Running Cost	Description	2016	2017	2018	2019	Total
1	Travel	Travel for international conferences	46,769	45,724	43,681	51,018	187,192
2	Conference	Registration	9,354	9,145	8,736	10,204	37,439
3	Special licences	special analysis software	9,354	9,145	8,736	10,204	37,439
4	Publishing	Articles and information materials	4,677	4,572	4,368	15,305	28,922
5	Analysis	Demonstration	0	0	13,541	0	13,541
6	Durable equipment	Workstation	9,354	0	0	0	9,354
	Total		79,508	68,586	79,062	86,731	313,887

Depreciation costs

Depreciation cost	Description	2016	2017	2018	2019

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	2019	Total, applied	Other costs	Total cost
Salaries including social fees	624,910	632,325	625,212	755,784	2,638,231		2,638,231
Running costs	79,508	68,586	79,062	86,731	313,887		313,887
Depreciation costs					0		0
Premises	49,993	50,586	50,017	60,463	211,059		211,059
Subtotal	754,411	751,497	754,291	902,978	3,163,177	0	3,163,177
Indirect costs	245,589	248,503	245,709	297,022	1,036,823		1,036,823
Total project cost	1,000,000	1,000,000	1,000,000	1,200,000	4,200,000	0	4,200,000

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

In this project, input from PI will reach 60% of full time and input from the PhD student will reach 80% of full time.

The total budget of the project is 8966641 kr. Among them, LTU will support 4766641 kr (if the project is approved). Therefore, the total amount from VR is 4200000 kr. Details can be found in Table.1. The support ratio from VR each year will be about 0,48. The costs are calculated following this support rate.

Table.1

Financing	2016	2017	2018	2019	Total
VR	1000000	1000000	1000000	1200000	4200000
LTU	1138150	1187036	1289332	1152123	4766641
Total	2138150	2187036	2289332	2352123	8966641

In summary, VR will support:

1. 28% of PI's salary; 37% óf one PhD student's salary. About 3.5% of salary's increasing rate has been considered for the four years period.
2. Premises cost include the office rent. The figure is follwoing LTU's statistics in 2013;
3. Running costs include:
    - travel for international conference, 2 people and twice per year;
    - registration for international conference,2 people and twice per year;
    - special license for special analysis tools, including Bayeslab;
    - publishing articles in Open access database;
    - Demonstrator's development and test;
    - Some study will be carry on in workstation.
4. Indirect costs include:
    - indirect costs for LTU (24%)
    - indirect costs for department (12%)
    - IT (3.3%)

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

	Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018	2019	Total
1	LTU	Jing (Janet) Lin	Research grant		1,138,150	1,187,036	1,289,332	1,152,123	4,766,641
	Total				1,138,150	1,187,036	1,289,332	1,152,123	4,766,641

CV and publications

CV

0. Personal Information

Family name, First name: Lin, Jing (Chinese); Lin, Janet (English)
Date of birth: May 5, 1980
Nationality: Chinese
URL for web site: http://www.ltu.se/staff/l/linjan-1.50327
Title Associate Professor
ORCID ID 0000-0002-7458-6820
E-mail address: janet.lin@ltu.se

1. Higher education qualification (s)

Sep 2003 -Apr 2008 PhD studies on Management Science and Technology from Nanjing University of Science and Technology, China (**Direct PhD program**, without MD; acceptance rate: <1/300 in my department in 2003)

Sep 1999 -Jul 2003 Bachelor studies on Business Management from Nanjing University of Science and Technology (**NJUST**), China.

2. Degree of Doctor

30th, Apr 2008 PhD, Management Science, Nanjing University of Science and Technology (**NJUST**), China; **Dissertation** "Bayesian Survival Analysis Based on MCMC Method and its Application in Reliability". Supervisor: Professor Yuqi Han.

3. Postdoctoral positions

Feb 2011 – Aug 2011 Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology (**LTU**), Sweden.

Aug 2009 – Dec 2010 Department of Computer Science, Electrical and Space Engineering, Luleå University of Technology (**LTU**), Sweden.

Aug 2008 – Aug 2009 Department of Business Management, Hunan University (**HNU**), China.

4. Qualification required for appointment as a docent: 17th March 2015

5. Present position

Mar 2015 - current Associate Professor at Luleå University of Technology, Sweden; research: 80%.

6. Previous positions and periods of appointment

Jul 2013 - Feb 2015 Assistant Professor, Luleå University of Technology, Sweden.

Aug 2011 - Jun 2013 Researcher, Luleå University of Technology, Sweden.

Mar 2008 - Jan 2011 Asset Management Consultant, SKF Co., Ltd., China.

7. Interruptions in research

Reason	Start of period	End of period	Percentage	Total deductible time
Parental leave	10-06-2014	30-09-2014	100%	4 months

8. Supervision

Currently, an assistant supervisor of two PhD students:

- Liangwei Zhang (Big Data Analytics in Maintenance)
- Matthias Asplund (Condition Based Maintenance in Railway)

9. Other information of relevance to the application

9.1 Peer-review assignments for journals

Reliability Engineering and System Engineering (SCI); Quality and Reliability Engineering International (SCI); IEEE transactions on Reliability (SCI); IEEE transactions on Systems, Man and Cybernetics: Systems (SCI);Testing and Evaluation (SCI); IET Intelligent Transport Systems (SCI); Computer Methods and Programs in Biomedicine (SCI); Microelectronics Reliability (SCI);International Journal of Quality & Reliability Management; International Journal of Systems Assurance Engineering and Management; International Journal of Quality in Maintenance Engineering; COMADEM International (Condition Monitoring and Diagnostic Engineering Management); Science and Technology Innovation Herald (in Chinese).

9.2 Expert assignment for international conference

Session Chair in the 2008 IEEE IEEM, Singapore; Program committee of eMain2014, Sweden; Program committee of ICRESH-ARMS2015, Sweden.

9.3 Memberships of scientific societies

Institute of Electrical and Electronics Engineers (IEEE), USA; PMI (Project Management Institute) Global Operations Center, USA; International Society for Bayesian Analysis (ISBA), UK.

9.4 Invited speech

- "Using Integrated Reliability Analysis to Optimize Maintenance Strategies", Invited speech for online Reliability Webinar Series, organized by American Society for Quality (ASQ), Silicon Valley, California, USA, October 2013;
- "Bayesian survival analysis with MCMC", Invited speech by Chalmers University of Technology (Sweden), Chair Professor Rikard Söderberg in Product and Production Development, May 2010;
- "Advanced Asset Management Service", Invited speech for postgraduate students, organized by Guangxi University of Science and Technology, China, October 2010;
- "How to publish paper in high quality journals", Invited speech for PhD students, organized by Hunan University, China, November 2009.

9.5 Entrepreneurial achievements

Project Management Professional (PMP®) since 2010, Project Management Institute, USA; Qualification Internal Auditor (ISO/TS 16949:2009) at SKF in 2010.

9.6 Teaching activities

- 2015: "Reliability in Maintenance Engineering", for undergraduate students at LTU;
- 2012-2015: "RAM (Reliability, Availability and Maintainability)", for undergraduate students at LTU (a part of D0004B);
- 2011: "RCA(Root Cause Analysis)", for undergraduate students at LTU (a part of D7004B);
- 2008-2010: Training industrial people in Asset Management, including: "RAMS (2008-2010)/ Advanced Maintenance Management (2009, 2010)/ Spares Management (2008-2010)/ RCA (Root Cause Analysis) (2009 & 2010)" at SKF (China) Co., Ltd..
- 2004: "MIS (Management Information System)", for undergraduate students at School of LANTIAN technological academy, Nanjing, China.
- 2005: "Production & Operations Management", for undergraduate students at NJUST, China.

9.7 Fellowships and awards

2011	Postdoc Research fellowship (Scholarship) in operation and maintenance, LTU, Sweden;
2009-2010	Postdoc Research fellowship (Scholarship) in Signal Process, LTU, Sweden;
2008-2009	Postdoc Research fellowship in Business Management, HNU, China;
2008	Quality Star in SKF Co. Ltd (twice, that year);
2007	Title of excellent graduate student in NJUST, China (NJUST), for academic excellence and outstanding performance in extracurricular activities;
2007	Special Innovation Award of China National PhD Candidates Academic Conference;
2007	First prize Directorate Scholarship in NJUST;
2007	Title of excellent graduate student of Commission of Science Technology And Industry for National Defense (COSTIND), China;
2006	Third prize China Aerospace Science Corp (CASC) Scholarship, China;
2004-2006	Title of excellent graduate student in NJUST for academic excellence and outstanding performance in extracurricular activities;
2006	Special Innovation Award of Innovation Cup in NJUST;
2005	Innovation Award for Graduate Student in Jiangsu Province, China;
2005-2007	Innovation Award for Graduate Student in NJUST, China;
1999-2003	Scholarship in every academic year in NJUST, China.

Publication list

To date, I have published 1 monograph, 2 book chapters, 1 doctoral thesis, 2 research reports[1], 2 newsletters, and **43** scientific papers. Among the published scientific papers[2]: **30/43 are published for peer-review journals; I am the first author in 33/43; 25/43 are published without my PhD supervisor** in a number of fields (incl. reliability, maintenance engineering, asset management, operation research, economics.).

Peer-reviewed original articles in journals[3]

1. ***Lin J**, Pulido J, Asplund M. Reliability Analysis for Preventive Maintenance based on Classical and Bayesian Semi-parametric Degradation Approaches using Locomotive Wheel-sets as a Case Study. Journal of Reliability Engineering and System Safety. **2015**, 134: 143-156 **(SCI Journal)**
2. ***Lin J**, Asplund M. Bayesian Semi-parametric Analysis for Locomotive Wheel Degradation using Gamma Frailties. Institution of Mechanical Engineers. Proceedings. Part F: Journal of Rail and Rapid Transit. **2015**, 229 (3):237-247 **(SCI Journal).**
3. ***Lin J**, Asplund M, Parida A. Reliability Analysis for Degradation of Locomotive Wheels using Parametric Bayesian Approach. Journal of Quality and Reliability Engineering International. **2014**, 30 (5): 657-667 **(SCI Journal)**
4. ***Lin J**, Asplund M. A Comparison Study for Locomotive Wheels' Reliability Assessment using the Weibull Frailty Model. Journal of Eksploatacja i Niezawodnosc - Maintenance and Reliability. **2014**; 16 (2): 276-287 **(SCI Journal)**
5. **Lin J.** An Integrated Procedure for Bayesian Reliability Inference using Markov Chain Monte Carlo Methods. Journal of Quality and Reliability Engineering. 2014 (2014). http://dx.doi.org/10.1155/2013/264920
6. **Lin J,** Lundberg Nordenvaad M., Zhu H M. Bayesian Survival Analysis in Reliability for Complex System with a Cure Fraction. International Journal of Performability Engineering. 2011, 7 (2): 109-120
7. **Lin J.** Requirements Predictive Models for Spares toward to Customers. Chinese Journal of Science and Technology Innovation Herald. 2010, 01:14-15 (in Chinese)
8. **Lin J**, Dong L., Zhang L W. Spares Management with PDCA. China Plant Engineering. 2010, 01:25-28 (in Chinese)
9. ***Lin J.** A Two-stage Failure Model for Bayesian Change Point Analysis. IEEE Transactions on Reliability. **2008**,57(2): 388-393 **(SCI Journal)**
10. **Lin J**, Chen J. Semi-parametric Shared Frailty Model Based on MCMC Method and its Application in Reliability. Electronic Product Reliability and Environmental Testing. China. 2008, 26 (153): 51-57 (in Chinese)
11. Y Han, **Lin J,** Han Y Q. Demand Risk's Evaluation for Supply Chain of Multinational Rag Trade Company. Journal of HUAIYIN TEACHERS COLLEGE. China. 2008, 30(3): 378-381 (in Chinese)
12. Zhu H M, S Liu, K Yu, **Lin J.** Bayesian Analysis of Stochastic Volatility Model Using Gibbs Sampling. Journal of Hunan University (Natural Sciences). China. 2008, 35 (12):88-92 (in Chinese)

[1] Some reports are not published due to confidential reasons;
[2] The full publication list can be found in http://www.ltu.se/staff/l/linjan-1.50327;
[3] The most five important publications are denoted with asterisks (*).

13. **Lin J.** Study on Evaluation of Storage Reliability for Ammunition. Journal of China Ordnance. 2007,3(4): 268-271 (in Chinese)
14. **Lin J,** Han Y Q, Zhu H M. Bayesian Analysis for Weibull Randomly Truncated Accelerated Life Testing Based on MCMC Method. Journal of Systems Engineering and Electronics. 2007, 29(2): 320-323 (in Chinese)
15. **Lin J**, Han Y Q, Zhu H M. The Reliability Models of Ammunition Storage based on MCMC Simulation Method. Journal of ACTA Armamentar. 2007, 28(3): 315-318
16. **Lin J**, Han Y Q, Zhu H M. A Cure Rate Model Based on MCMC Method and its Application in Reliability Evaluation for Complex System. Journal of Mathematics in Practice and Theory. 2007, 37(7): 69-75 (in Chinese)
17. **Lin J**, Han Y Q, Zhu H M. Gamma Process Priors Model based on MCMC Simulation and its Application in Reliability. Journal of system simulation. 2007, 19 (22): 5099-5102(in Chinese)

Note that, most Chinese journals the papers I published before 2008 (during my PhD study) are top academic journals in China (**one for each PhD student is required by my University for achieving PhD degree; when I graduated, I have nine in such kinds of journals**). These include: Chinese Journal of Management Science, China Journal of Engineering Science, China Journal of Mechanical Engineering, Chinese Journal of Operations Research & Management Science, Chinese Journal of Operations Research & Management Science, and Chinese Journal of Quantitative & Technical Economics (SCI or EI indexed).

Peer-reviewed conference contributions

1. **Lin J**, Asplund M, Nordmark T. Data Analysis of Wheel-sets' Running Surface Wear Based on Re-profiling Measurement: A Case Study at Malmbanan. The 11th International Heavy Haul Association Conference (IHHA 2015). 21-24 June, Perth, Aruba, Australia. 2015. Accepted
2. **Lin J**, Pulido J, Asplund M. Analysis for Locomotive Wheels' Degradation. The 60th Annual Reliability and Maintainability Symposium (RAMS® 2014). Conference Proceedings. 27-30 January, Springs, Colorado, USA. 2014.
3. **Lin J**, Asplund M, Parida A. Bayesian Parametric Analysis for Reliability Study of Locomotive Wheels. The 59th Annual Reliability and Maintainability Symposium (RAMS® 2013). Conference Proceedings. 28-31 January, Orlando, FL, USA. 2013
4. Mikael P, **Lin J**, Per-Olof Larsson-Kråik. Maintenance Performance Improvement for Rolling Stock Wheels. 2013 Prognostic and System Health Management (PHM2013). Conference Proceedings (and Journal of Chemical Engineering Transactions. 2013, 33: 727-732). 8-11 September, Milan, Italy. 2013.
5. **Lin J**, Ghodrati, B. Information Sharing in a Spares Demand System. 2012 IEEE International Conference on Technology Management (ITMC2012). Conference Proceedings. 24-27 June, Dallas, TX, USA. 2012
6. **Lin J**, Lundberg Nordenvaad, M. Spares Demand System with Consideration of Integration Management and Optimization. 2011 International conference of Mechanical, Industrial, and Manufacturing Engineering (MIME2011). Conference Proceedings. 15-16 January, Melbourne, Australia. 2011
7. **Lin J**, Ghodrati B., Kumar U. House of Maintenance Management in Mining Industry. 2011 IEEE International Conference on Quality and Reliability (ICQR11). Conference Proceedings. 14-17 September, Bangkok, Thailand. 2011

8. **Lin J**, Ghodrati B. A Step-by-Step Model to Improve Delivery Assurance: A Case Study in Mining industry. 2011 IEEE International Conference on Quality and Reliability (ICQR11). Conference Proceedings. 14-17 September, Bangkok, Thailand. 2011
9. **Lin J**, Ghodrati B. Maintenance Spares Inventory Management- Performance Measurement using a HOMM. 2011 Maintenance Performance and Measurement and Management (MPMM2011). 14-15 December, Luleå, Sweden. 2011
10. **Lin J**, Zhu H M. A Cure Rate Model in Reliability for Complex System. 2008 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2008). Conference Proceedings. 8-11 December, Singapore. 2008
11. **Lin J**, Chen J, Han Y Q. Bayesian Analysis of Constant-Stress AFT for Weibull Distribution using Gibbs sampler. 2007 IEEE International Conference on Grey System and Intelligent Services (GSIS 2007). Conference Proceedings. 18-20 December, Nanjing, Jiangsu, China. 2007

Monografier

1. Zhu H M, **Lin J**. Bayesian Econometrics. Beijing. China Science Press. ISBN# 978-7-0302-5140-4. Sep, 2009. (in Chinese)

Books and book chapters

1. **Lin J**, etc. Chapter 18 “Quality Assurance Engineering” in the handbook of “Enterprise driven Industrialization”, ISBN# 7-5641-0160-1. 2005. (in Chinese)
2. Translator of “Chapter 10： Capacity Planning and Utilization” in the Chinese version of “Manufacturing Planning and Control for Supply Chain Management (fifth Edition)”. ISBN: 9787300099521. 2008. Organized by: Professor Yuqi Han. (in Chinese)

Popular science articles/presentations

1. October 2013: Invited speech for online Reliability Webinar Series, on “Bayesian survival analysis with MCMC”, organized by American Society for Quality (ASQ), Silicon Valley, California, USA.
2. May, 2010: Invited speech by Chalmers University of Technology, Sweden, Chair Professor Rikard Söderberg in Product and Production Development, on “Bayesian survival analysis with MCMC”.
3. October, 2010: Invited speech for Master students, on “Advanced Asset Management Service”, organized by Guangxi University of Science and Technology, Liuzhou, Guangxi, China.

Others

Report

1. **Lin J.** Data Analysis of Heavy Haul Locomotive Wheel-sets’ Running Surface Wear at Malmbanan. Research Report. Published by: Luleå University of Technology. ISSN: 1402-1528; ISBN: 978-91-7439-898-4 (tryckt); ISBN: 978-91-7439-899-1 (pdf). 2014, April
2. **Lin J**. Using Integrated Reliability Analysis to Optimise Maintenance Strategies – A Bayesian Integrated Reliability Analysis of Locomotive Wheels. ResearchReport. Published by: Luleå University of Technology. ISSN: 1402-1528; ISBN: 978-91-7439-600-3 (tryckt); ISBN: 978-91-7439-600-3 (pdf). 2013, May

Newsletter

1. **Lin J.** Bayesian Integrated Reliability Analysis for Locomotive Wheels. Newsletter of European Safety and Reliability Association. Jun 2013
2. **Lin J.** Data analysis of heavy haul locomotive wheel-sets' running surface wear at Malmbanan. Newsletter of European Safety and Reliability Association. Sweden. March 2014.

PhD thesis

1. **Lin J.** Bayesian Survival Analysis Based on MCMC Method and Its Application in Reliability. Nanjing University of Science & Technology (NJUST), China. 2008

Summary

Table 1 Summary of Publications

Year	Journal Articles[4]	Conference Articles	Monograph	Book Chapters	Reports	newsletters	PhD Thesis	Total
2015	2 (2)							2
2014	3 (3)	1 (1)			1	1		6
2013		2 (1)			1	1		4
2012		1 (1)						1
2011	2 (1)	4 (4)						6
2010	2 (2)							2
2009			1					1
2008	4 (2)	1 (1)		1			1	7
2007	6 (6)	1 (1)						7
2006	5 (5)	2 (1)						7
2005	5 (2)	1 (0)		1				7
2004	1 (0)							1
Total	30 (23)	13 (10)	1	2	2	2	1	51

[4] The number of articles published as the first author is marked in "()".

CV

Name: Jing (Janet) Lin	**Doctorial degree:** 2008-04-30
Birthdate: 19800505	**Academic title:** Docent
Gender: Female	**Employer:** Luleå Tekniska Universitet

Research education

Dissertation title (swe)

Bayesian Survival Analysis Based on MCMC Method and Its Application in Reliability

Dissertation title (en)

Bayesian Survival Analysis Based on MCMC Method and Its Application in Reliability

Organisation	Unit	Supervisor
Nanjing University of Science & Technology, China Not Sweden - Higher Education institutes		Yuqi Han

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
21199. Övrig annan teknik		2008-04-30

Publications

Name: Jing (Janet) Lin	**Doctorial degree:** 2008-04-30
Birthdate: 19800505	**Academic title:** Docent
Gender: Female	**Employer:** Luleå Tekniska Universitet

Lin, Jing (Janet) has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.