European Safety and Reliability Association

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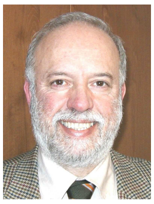
EDITORIAL



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We are happy to see that more contributions are flowing in for the ESRA Newsletter, which will allow it to increase its periodicity.

In this number we have a contribution for the Technical Committee on Natural hazards, dealing with the problems of Flood risk. We have also a feature article dealing with the problem of lack of reliability data, which, although more technical than is usual in Newsletter contributions, still brings attention to this problem.

There are also information about activities in the various countries, namely about the work done in Norway on reliability assessment of safety instrumented systems, a topic that is attraction the attention in different countries.

There is also a special contribution from our colleagues in Brazil, which reflects the interest that ESRA is attraction outside the boundaries of Europe. Although a European based organization ESRA allows for Associate members from non-European countries and we have seen an increased number of cases of non-European organizations asking to become associate members. This is a tendency that is most welcome.

The sections with information about concluded thesis and about reliability event are also included.

CONTRIBUTIONS FROM ESRA TECHNICAL COMMITTEES

What happened after the Katrina Flood?

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One of the biggest natural disasters in the United States of America was the impact of the Katrina hurricane in 2005. The city of New Orleans flooded almost completely and more than 1000 fatalities have been counted. For the people who lived in New Orleans there are two worlds now: one before Katrina and one after Katrina. One of the most impressive books about this the impact on human live conditions of this disaster is 'Code Blue: A Katrina Physicians Memoir' by dr. Deichman. He tells the inside story of the hellish nightmare of those who struggled to survive the ordeal were cast into. Bodies stacked up in the chapel as the temperature soared in the overcrowded hospital and the situation became increasingly desperate. Doctors, nurses and staff worked around the clock caring those inside and trying to evacuate the facility. They expected that the government would help them to evacuate, but after three days of surviving the hospital was evacuated without support of the governmental agencies. Allegations of euthanasia in this hospital would later make headlines across the world, but these rumors lacked any basis in reality.

The Katrina disaster happened four years ago. The city of New Orleans is not rebuild completely yet, and it is expected that it will also not be rebuild completely. About one third of the population did not return to the city and live now somewhere else. Before the flood, New Orleans was already a city in decline, and that does not help to rebuild the city. The economic condition of the region is still not very healthy, but the safety against flooding has been improved in the past few years. The flood defences have been rebuild, and are in a better state than before the flood. Also, storm surge barriers are build now to keep the storm surge water out of the city. It is always a pity that such a big disaster is necessary in order to take the necessary protection measures. It is estimated that the flooding probability will be improved from 1/30 before the Katrina flood to 1/100 yr^{-1} after the proposed measures are implemented. But is that safe enough? In the Netherlands, for example, we have protection levels of 1/10.000 yr^{-1}, that is almost a factor 100 higher than in the USA. This topic has been studied in the 'Dutch Perspective' study, in commission of the US Army Corps of Engineers by a Dutch consortium of experts. Part of the study has been the answer of the question "how safe is safe enough". The results of the study are reported in Results of the Risk Analysis are also reported in the article of Jonkman *et al*., 2009.

"How safe is safe enough?" This question is a classical question. However, it has to be answered in the design of engineering systems. The question is how much safety society desires at which costs, and thus how much risk is tolerated. This is of course a political decision. However, information about the consequences of this decision is often desirable, and risk management techniques may be helpful to provide this information ("risk based informative decision making"). Risk is generally defined as the product of probability and consequences. The principles of risk analysis are widely used in several engineering fields, for example in nuclear and chemical engineering. In Flood Risk management, we see a tendency that risk analysis techniques are applied more often. The consequences are often measured in 'economic damage' and 'loss of life'.

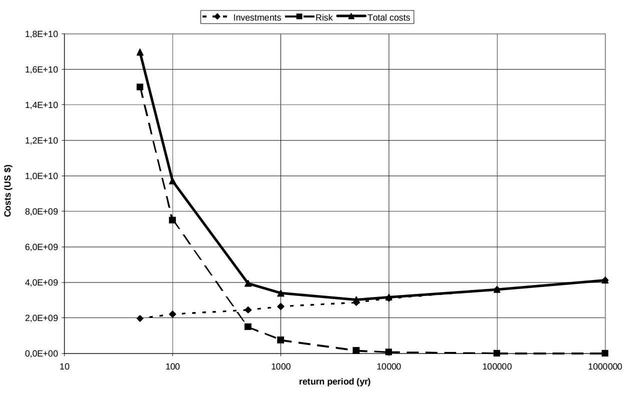

Figure 1 - Results of economic optimization for the Northern dike ring, central part of New Orleans (Jonkman et al, 2009)

In the *Dutch perspective on Coastal Louisiana* the Risk Based Design approach of flood protection systems has been applied to the New Orleans metropolitan area. In the so-called economic optimization the incremental investments in more safety are balanced with the reduction of the risk to find an optimal level of flood protection. Although the analyses are preliminary and not yet fully realistic the presented outcomes indicate that for densely populated areas, such as the central parts of New Orleans, it could be justified to choose a higher protection level than the currently proposed level of $1/100yr^{-1}$. In figure 1 the results of a simplified cost-benefit analysis are shown for one of the dike-ring areas in New Orleans. It can be seen that even higher protection levels of 1/1000 yr^{-1} can be defended on economic grounds. The results of the economic optimization can be considered as technical advice that can be used as input for the (political) decision-making. Adding loss of life issues would result in even higher protection levels. It is an interesting question how to include 'loss of live' in establishing protection levels against flooding in low-lying countries. In a new article we will elaborate on this issue.

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J. Dijkman, et al. *A Dutch Perspective on Coastal Louisiana. Flood Risk Reduction and Landscape Stabilization*, Netherlands Water Partnership, in commission of the USA Corps of Engineers, 18 October 2007.

FEATURE ARTICLES

Exact testing with small samples, censored and missing data

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Abstract

Timely and accurate reliability data is needed to aid in decision making. Life data of a component, product or system are often incomplete. For a variety of reasons over 90% of the data in the Reliability

Analysis Centre (RAC) does not have the individual failure times recorded.

Exact testing procedures are of a high relevance today, since in more and more situations samples are rather small. The aim of this presentation is to introduce the exact likelihood ratio testing of scale homogeneity and a simple scale parameter hypothesis of a life type distribution. The real data illustration of given methods will be also provided.

Introduction

In a general reliability problem we can face one (or more) of the following issues: a) small sample, b) missing data, or c) censored data. Incomplete data are a common topic in many statistical investigations. Here we concentrate on homogeneity and scale testing for small samples with missing time-to-failure or censored information. Such a situation is typical for reliability predictions and analysis. Reliability prediction plays a major role in many reliability programs across government and industry. The reliability prediction is the process of forecasting, from available failure-rate information, the realistically achievable reliability of a part, component, subsystem or system. Standards based reliability (see e.g. www.weibull.com) predictions relies on defining failure rates for the components of a system based on predefined standards, depending on the types of components, the use environment, the way the components are connected and the reliability prediction standard. These component failure rates are then used to obtain an overall system failure rate. Several standards have been introduced by various governments and industry organizations to assist in conducting this type of analysis.

Complete data indicates that all of the units under the test failed and the time-to-failure for each unit is known. Therefore, complete information is known regarding the entire sample. However, data collection is generally performed passively by the system owner and such type of data collection is often uncontrolled and important details are not always recorded or they can be lost. The actual times-to-failure are often not recorded even though the failure itself has been carefully noted. E.g. for a variety of reasons over 90% of the data in the Reliability Analysis Centre (RAC) does not have the individual failure times recorded (see [2]). Many large organizations such as the national airlines or train systems and utility companies develop reliability databases to track the field reliability on the systems they operate and maintain. The magnitude of such efforts often leads to compromises in the level of details tracked on the system and component failures. For the assessment of component reliability, field data has many distinct advantages. For all of the advantages of the field data, there are also disadvantages, including incomplete or inaccurate data reporting and others. The disadvantage to be addressed in [2] is the fact that the individual times-to-failure are often missing. There has been other research concerned with the use of data with missing attributes. In [3] the exact likelihood ratio test for the scale and homogeneity in the complete sample from gamma family is derived, later on the exact likelihood ratio test for the scale and homogeneity in the complete sample from Weibull family is derived and in [4] the generalization for the complete sample from generalized gamma family is given. The exact likelihood ratio test for the scale parameter in the Type I, Type II and progressively Type II censored Weibull sample is derived in [1]. The approach for exact likelihood ratio testing for the scale and homogeneity with the missing time to failure exponentially distributed was also applied.

To illustrate the exact testing procedures let us consider the exact likelihood ratio test of the *scale hypothesis*

$$H_0: \lambda = \lambda_0 \text{ versus the alternative } H_1: \lambda \neq \lambda_0$$

and *scale homogeneity hypothesis*

$$H_0: \lambda_1 = \lambda_2 = \ldots = \lambda_n$$

versus the general alternative non H_0, where life times (complete, missing, censored) are generalized gamma distributed. That means that observation y_i has probability density of the form

$f(y_i|\theta_i) = \alpha(y_i/\lambda_i)^{\beta}\exp(-(y_i/\lambda_i)^{\alpha})/(\lambda_i\Gamma((1+\beta)/\alpha))$, for $y_i > 0$, and $\theta_i = (\alpha, \beta, \lambda_i)$. The generalized gamma distribution is one of the most studied probability density functions of statistics since many of the important nondiscrete density functions can be derived from it. For example, $f(y|(2, 0, (2\lambda)^{1/2}))$ is the one-sided normal distribution and $f(y|(1, n/2-1, 2))$ is the χ^2_n-distribution. In the special case of $\beta = \alpha - 1$ the gamma distribution is called a Weibull distribution and in the case of $\alpha = 1$ we obtain the Gamma distribution.

In particular a reliability practitioner could be interested in conducting this hypothesis test, e.g. to see whether the field reliability has significantly changed from its current level, and "λ_0" could be the previously observed scale parameter. Then, a significant shift in the scale parameter could trigger an exploratory reliability investigation into failure causes and mechanisms, if it got worse.

We have developed also scale homogeneity hypothesis to test the homogeneity of life times to failure against various alternatives (see [4] and references therein).

Such a test could be useful also for a mean time to failure (MTTF) analysis. A component or a system with exponential lifetime and rate parameter γ has MTTF $1/\gamma$. Moreover, such a test could be employed also by analysis of a system described by a Markov diagram with only one route through the diagram and constant transition rates. The system has MTTF consisting of the sum of mean times spent in each state, i.e. $1/\gamma_1 + 1/\gamma_2 + \ldots$

The data is often available only in the form of collective failures observed cumulative hours with no further delineation or detail available (see [2]). Analysts may have many of these merged data records available for the same component. We have developed a general approach for the missing data by relaxing an aggregation function on the complete data sample. To be more specific, we consider that instead of observing a complete sample of times-to-failure, we observe a smooth missing function of it. A typical example of such a missing structure involves aggregations, i.e. reliability manager observes the only cumulative times. Table 1 presents a data set of this type; the data on aircraft indicator lights from the database RAC (see [2]). Individual time-to-failure is not available; however, the total number of failures and the cumulative operating hours are recorded. Here T_j is the j-th cumulative operating time with r_j failures.

Table 1: Airplane indicator light reliability data

Failures	Observed aggregated time	Cumulative operating time (hours)
2	T_1	51 000
9	T_2	194 900
8	T_3	45 300
8	T_4	112 400
6	T_5	104 000
5	T_6	44 800

In [5] we modelled the aggregation for a Pareto and a generalized Gamma distribution life models. The exact likelihood ratio test of homogeneity and Pareto tail index was derived in [6]. This distribution may be used in the analysis of business failure data. The length of wire between flaws also follows a Pareto distribution.

In [5] we do not put conditions on individual times-to-failure. The special cases of reliability situation satisfying these assumptions consist of a classical model for missing individual times-to-failure as given in [2] and later generalized in our work. The latter reliability situation consisted of

- times-to-failure are independent, identically distributed
- times-to-failure are generalized gamma distributed. Special cases of generalized gamma are e.g. exponential, Erlang and gamma distributions. The exponential distribution often occurs in the modelling of the time-to-failure; see e.g. the software-reliability model of Moranda. Erlang and gamma distribution are also often used time-to-failure distributions (see [2]).
- repair times are insignificant compared to operating time
- system repair does not degrade or otherwise affect the reliability of the not failed components.

The assumption in [5] is also satisfied with the novel missing data mechanism for Pareto distribution.

Remark: Note that the asymptotical χ^2-test is oversized and thus inappropriate especially for small merged samples. The small merged samples can arise also for a large sample sizes when individual times-to-failure are not available. Data sets with missing time-to-failure data can arise from field data collection systems.

In [5] we derived the exact likelihood ratio test of scale homogeneity hypothesis for observed aggregated times being independent and gamma distributed with unknown scale parameters and a known, potentially different shape parameters. The latter is caused by the missing time-to-failure mechanism. The exact LR test of homogeneity against the general alternative for complete sample has been introduced by [4]. The small and mid sample properties of this test, also called ELRH and test against the 2 component mixture for exponential complete samples have been also studied.

Conclusions

This paper could be taken partially as a critique of misusing the χ^2 asymptotics for small samples. We have found, especially for extremely small samples frequently occurred by reliability engineering experiments, the exact likelihood ratio test to be more appropriate. In cited papers, an exact testing procedure for scale and homogeneity hypotheses has been developed when the times-to-failure are missing according to the analytical mechanisms. These mechanisms encompass well both the standard life time models with missing times-to-failure and heavy tailed Pareto life time model with missing times-to-failure. Data sets with missing time-to-failure data can arise from field data collection systems. The advantages of this approach are:

- we provide the power-function in the explicit analytical form for the scale hypotheses
- the exact LR test of the hypothesis is unbiased uniformly most powerful (UUMP) for the scale hypothesis
- the provided testing procedures for scale and homogeneity hypotheses can be easily implemented to the computational software in terms of Lambert W function, gamma cumulative distribution function and random generator of Dirichlet distribution.

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NEW FROM DIFFERENT COUNTRIES

PDS handbooks for reliability assessment of safety instrumented systems

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The PDS method

PDS[1] is a method used to quantify the unavailability of safety instrumented systems (SIS) as required in international safety standards like IEC 61508 and IEC 61511. The PDS method is widely used in the petroleum industry, but is also applicable to other business sectors. The method has been developed in close co-operation with oil companies as well as vendors and researchers of control and safety systems.

The PDS method is documented through a method handbook and a data handbook. The PDS handbooks present simple calculation formulas together with generic reliability data. Recently, the handbooks have been extended to provide formulas also for continuously (high demand mode) operating systems.

Reliability prediction

Predicting the future reliability performance of equipment and systems is a challenging subject full of pitfalls and conflicting interests. On the one hand, equipment manufacturers obviously want to demonstrate reliability figures that are as good as possible. On the other hand, plant operators and authorities should obtain reliability prediction figures that reflect how the equipment is actually going to operate once installed in the field. Questions related to how reliability predictions shall be performed and what a reliability analysis shall include therefore frequently arise. PDS is a method that has been developed to answer these questions in a realistic and as simple as possible manner. The method is primarily used to quantify the safety unavailability of SIS but also include data for quantifying loss of production due to trip failures.

Figure 1 The updated PDS handbooks

Failure types included in PDS

Failures can be categorised according to failure cause. In the international safety standard, IEC 61508, one differentiate between *random hardware failure* and *systematic failures*. PDS uses the same classification, but suggests a more detailed breakdown of the systematic failures, as indicated in Figure 2.

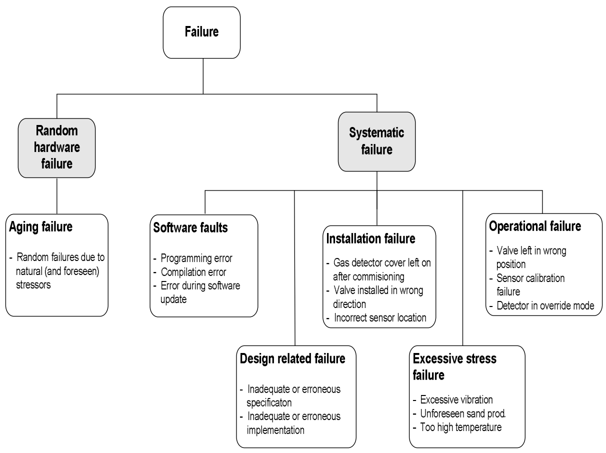

Figure 2 - Possible failure classification

Following the introduction of IEC 61508 and the accompanying SIL verification process, exaggerated performance claims have become an increasing

[1] PDS is the Norwegian acronym for "Reliability and availability of computer based safety systems".

problem. Why should failure rates claimed in the design phase be an order of magnitude (or more) better than what is normally experienced during operation? An important idea behind the PDS method is that the *predicted risk reduction* should reflect the *actual risk reduction* experienced in the operational phase. In the PDS method it is therefore argued that both the contribution from random hardware failures as well as systematic failures should as far as possible be quantified. This is important since the contribution from systematic failures may often constitute a major part of the safety unavailability for a given SIS.

Common cause failures (CCF) in PDS

The traditional way of accounting for common cause failures (CCF) has been the β-factor model. In this model it is assumed that a certain fraction of the failures (equal to β) are common cause, i.e. failures that will cause all the redundant components to fail simultaneously or within a short time interval.

In the PDS method, we use an extended version of the β-factor model that distinguishes between different types of voting. Here, the rate of common cause failures explicitly depends on the configuration, and the beta-factor of a MooN voting logic is expressed by:

$$\beta(\text{MooN}) = \beta \cdot C_{\text{MooN},}\ (M<N),$$

By using this model, the parameter β is maintained as an essential parameter whose interpretation is now entirely related to a duplicated system. Further, note that the effect of voting is introduced as a *separate* factor, $C_{\text{MooN},}$ independent of β. This makes the model easy to use in practice.

Reliability data for calculations

The use of relevant failure data is an essential part of any quantitative reliability analysis. It is also one of the most challenging parts and raises a number of questions concerning the availability and relevance of the data, the assumptions underlying the data and what uncertainties are related to the data.

In the updated PDS data handbook, reliability data dossiers for field devices (sensors, valves, etc.) and control logic (electronics) are presented, giving proposed values for the most important reliability parameters. Efforts have been made to document the presented data thoroughly, both in terms of applied data sources and underlying assumptions.

Acknowledgements

Thanks to all my SINTEF colleagues working on the PDS project and to the members of the PDS forum for their input and comments to the handbooks. Thanks to the Norwegian Research Council for sponsoring this project.

For more information about the PDS method and the updated PDS handbooks, please visit www.sintef.no/pds.

Maintenance, Reliability and Risk Analysis: A Glance on the Brazilian Research

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R. J. P. Ferreira, (UFRN)

Brazil has been a target for several researchers with regard to its development as a promising developing country, and they have focused on interesting economic and social aspects.

For many years Brazil has been investing in expanding its research capabilities in several engineering areas, including in Safety and Reliability. During the 1950s the Brazilian Research Bureau (CNPq) was created, almost at the same time as Brazil's Nuclear Program and the Brazilian Oil and Gas Research Center of Petrobras (CENPES). Later on, in the 1970s, the Electrical Energy Research Center of Eletrobras (CEPEL) was founded.

This led to large investments in Brazilian research studies in several areas at the same time, which have had and continue to have a significant impact on research programs and research funding. Part of the income of power electrical and Oil companies is reserved for R&D funding, for example, which provides considerable resources for academia and innovation for these companies.

Throughout the country, researchers are actively working on Reliability and Safety. There are well-established research centres in the most regions of Brazil. At the Federal University of Pernambuco (UFPE) there are two research centres dealing with reliability; and the modelling of safety and maintenance systems. CEERMA is the most recent one and its main research subject is reliability engineering based on Simulation, Bayesian models and heuristics. GPSID (www.gpsid.org.br) is the longest established centre at UFPE and works on Reliability, Maintenance, Risk Analysis, Safety and Decision and Information Systems. Nearby, another group is emerging at the Federal University of Rio Grande do Norte (UFRN) which is developing research on maintenance modelling and condition monitoring systems.

In the southeast of Brazil there are several groups at the largest of the National Companies who have gained national and international recognition, including those at the Petrobras and Eletrobras research centers (CENPES and CEPEL). In terms of universities, COPPE / UFRJ is one of the largest universities in Brazil. Amongst other research groups working on reliability and safety, there is a research group for Nuclear Engineering Program working on Reliability engineering and Probabilistic Safety Assessment (PSA) of nuclear power stations; forecasting the reliability of safety systems which figures in the context of PSA, by considering stochastic point processes, Markov chains, Non-Markovian processes (for treating failures due to age that must be considered when addressing the useful life extensions of power plants under regulatory maintenance rule constraints) and dynamic approaches for facing the new challenges of digital systems (like the Dynamic Flow Model) under the risk-informed decision making framework. Nearby there is the Federal University of Minas Gerais (UFMG) where there is another active research group working on Reliability and Systems Maintenance, specially the reliability of repairable systems using fuzzy logic, life test and degradation models.

Moving farther South, at the Federal Technical University of Paraná (UTFPR) there is a research centre collaborating with Universities from Japan, which is undertaking research on predictive maintenance models and condition based maintenance using fuzzy logic to classify items in their degradation state. Another active research centre also in the South of Brazil is at the Federal University of Rio Grande do Sul. Its main subject interest is in the classical approaches of Reliability and Maintenance, with a strong focus on studies regarding warranty and reliability applications for industries. The most recent product of research from this centre is a book addressing Reliability and Industrial Maintenance, for undergraduate courses, supported by the Brazilian Production Engineering Society (ABEPRO), which was launched last October at the ABEPRO national conference.

Besides these research centres and groups described on this quick tour round Brazil, there are other groups which could be included. The aspect that was emphasized on this quick look at the Reliability and Safety status on Brazil was the diversity of different subjects and approaches being developed throughout a country of continental size and the potential of Brazil to contribute to the development of these important areas.

This can be seen from the studies arising from collaboration with the most important research centres around the world and the major papers published by these groups, in some of the most widely-respected journals: Reliability Engineering & System Safety, IEEE transactions on Reliability, Risk Analysis, European Journal of Operational Research, Safety Science, Annals of Operations Research, International Journal of Intelligent Systems, Quality and Reliability Engineering International, Computers & Industrial Engineering, Corrosion Science, Simulation Modelling Practice and Theory, Methodology and Computing in Applied Probability.

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PhD Degrees Completed

Maintenance decision support models for railway infrastructure using RAMS & LCC analyses

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Today’s railway sector is imposing high demands for service quality e.g. higher capacity, better punctuality and higher safety etc. on railway infrastructure. Since railway infrastructure has a long asset life, it requires efficient maintenance planning to perform effectively throughout its life cycle to meet these high demands. Traditionally maintenance decisions for the railway infrastructure have been based on past experience and expert estimations. The application of RAMS (Reliability, Availability, Maintainability and Safety) and LCC (Life Cycle Cost) analyses for railway infrastructure is limited.

A research project was initiated at Division of Operation and Maintenance Engineering, Luleå University of Technology, Sweden to develop RAMS and LCC based maintenance decision support models for railway infrastructure with funding from Swedish National Rail Administration (Banverket), ALSTOM Transport France and EU Structure funds for the project INNOTRACK. The project dealt with railway track system for heavy haul rail operation and signalling system of ERTMS (European Rail Traffic Management System) level 2 for high speed rail operation.

The purpose of the research was to illustrate and demonstrate the applicability of RAMS and LCC analysis in the decision making process governing the cost effective maintenance of the railway infrastructure, taking the associated risks and uncertainties into consideration. The research presents approaches and models for estimating RAMS targets based on the service quality requirements of the railway infrastructure. The availability target of the infrastructure has been estimated by considering the capacity and punctuality requirements of the infrastructure, whereas the safety goal of the track has been estimated by calculating the probability of derailment by means of undetected rail breaks and poor track quality. Effective estimation of the RAMS targets will help infrastructure managers to predict the maintenance investment in the railway infrastructure needed over a period of time in order to achieve the targets.

Nevertheless, the availability target of the infrastructure can lead to train delay. A model has been developed to achieve the availability target in both the scheduled and the condition based maintenance regimes by choosing an effective maintenance interval and detection probability respectively. This has been illustrated by a case study on track circuits. Different maintenance strategies can help in achieving the RAMS targets. In order to determine the cost-effective solution, LCC should be used. The maintenance strategy with lowest LCC will be the cost effective maintenance strategy. This has been demonstrated by a case study on a signalling system. Sensitivity analyses have been performed to calculate the maximum cost effectiveness of the system for different maintenance parameters.

LCC estimation for a maintenance strategy should always consider the risks associated with the strategy. A fair degree of uncertainty is also associated with LCC estimation due to the statistical characteristics of RAMS parameters. An approach has been developed in this thesis to calculate the uncertainties associated with LCC estimation. Petri-Net analyses, Monte Carlo simulations, Design of Experiment have been used to develop models to achieve the objectives of this thesis.

This research work discusses the applicability of RAMS and LCC analyses for railway infrastructure and demonstrates models for effective infrastructure maintenance planning. For more details, please contact Dr. Ambika Prasad Patra (ambika.patra@ltu.se) or Prof. Uday Kumar (uday.kumar@ltu.se).

The thesis can be downloaded from:
http://pure.ltu.se/ws/fbspretrieve/3340192

Development of Life Cycle Cost Model and Analyses for Railway Switches and Crossings

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***Main Examiner/Faculty Opponent**:*
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Infrastructure managers need to have a safe and available infrastructure, so that train operators can deliver a transport service at an affordable price. In the future, as traffic volume increases, higher utilisation of the existing capacity, less time for maintenance and fewer unplanned interruptions will be critical for meeting the ever increasing need of transport capacity. Improved performance and added capacity on the existing track can be achieved by optimising the operation and maintenance of infrastructure systems. In general, RAMS (Reliability, Availability, Maintainability and Safety) and LCC (Life cycle cost) analyses are used as tools to optimize the performance of infrastructure and make it economically viable. RAMS analysis is used to establish the need of maintenance by analysing corrective and preventive maintenance data. LCC is a method of highlighting the cost for investment, operation, maintenance and unplanned interruptions throughout an asset's life cycle.

This research project was initiated at Division of Operation and Maintenance Engineering, Luleå University of Technology, Sweden with funding from Swedish National Rail Administration (Banverket) and EU Structure funds for the project INNOTRACK. Switches and crossings (S&Cs) are one of the major subsystems in the superstructure of the railway. The major function of an S&C is to allow trains to shift from one track to another track in a safe way. To enable this, an S&C consists of movable and fixed mechanical parts, as well as signalling and electrical systems. Each of these systems has a need for maintenance and is susceptible to failures which ultimately lead to train disturbances. The investment costs for new S&Cs are high and the technical lifespan is often very long (up to 40 years). Therefore, the maintenance cost is considerable. If the S&C is causing many train interruptions, the cost for train delays is also an important factor for consideration.

During the course of this research study, reliability and maintainability characteristics of switches and crossings are analysed using real data from Banverket. In addition, an LCC model is developed using information from Banverket. By applying this model, correct maintenance and investment decisions can be made. Some parts of the Research work have been performed within the European Framework of FP 6 IP Project INNOTRACK with a goal of reducing the LCC of infrastructure by 30%.

This research study confirms that the infrastructure managers have enough data to apply the LCC models for the S&Cs. The model developed can be used to evaluate new S&C designs and to take decisions regarding alternatives for S&C specification to be used under different traffic situations. Also the issue of decisions regarding renewal versus extended life through maintenance is highlighted by use of the LCC model. For more details, please contact Dr. Arne Nissen (arne.nissen@banverket.se) or Prof. Uday Kumar (uday.kumar@ltu.se).

The thesis can be downloaded from:
http://pure.ltu.se/ws/fbspretrieve/3353789

Calendar of Safety and Reliability Events

13th International Symposium on Loss Prevention and Safety Promotion in the Process Industries
Brugge, 6-9 June 2010

Information about this event can be consulted on the Conference website at: www.lossprevention2010.com

Tenth Conference on Probabilistic Safety Assessment and Management (PSAM 10)
Washington (Seattle), 7-11 June 2010

This meeting will focus on the improvement of performance and safety of complex technological systems, economics, and environment - emphasizing the breadth of PSA applications including methodologies, technologies, and industries. In addition to a compelling technical program we will provide meeting attendees with the opportunity to enjoy the attractions of Seattle and the natural beauty of the Pacific Northwest coastal area.

Prospective meeting attendees are encouraged to submit an abstract by September 18, 2009 by following the instructions and forms that are provided at the following conference web site: http://www.psam10.org.

Important Dates:
Submission of Abstracts: May 18 - 15 Sep 2009
Notification to Authors: 16 Nov 2009
Full Paper Submission: 15 Feb 2010
Pre-Conference Workshop: 05-06 Jun 2010

ESREL 2010 European Safety and Reliability Conference,
Rhodes, 5 – 10 September 2010

The ESREL 2010 Conference will be held at the Rodos Palace Resort Hotel www.rodos-palace.gr. More information can be obtained at the following address: www.esrel2010.com.

Important Dates:

Submission of Abstracts: 15 January 2010
Submission of full-length paper: 30 April 2010

The 19th SRA-Europe Annual Meeting
London, 21-23 June 2010

The special theme of this conference will be "Risk, Governance & Accountability".

Website: www.kcl.ac.uk/sspp/srae2010 .

Important dates 2010
Receipt of abstracts: 29 January 2010

5th International Conference on Safety.net
Røros, 7-10 September 2010

The main theme of the conference is 'On the road to vision zero?' Related to this topic, the main focus will be on the prevention of accidents at work, and especially on the understanding and prevention of occupational accidents; however, major accidents resulting in loss of lives and health in industry and transportation are also within the scope of the conference.

Website: www.wos2010.no

Important Dates
Submission of Abstracts: 15 February 2010
Submission of full-length paper: 1 July 2010

8th International Probabilistic Workshop
Szczecin, Poland, 18-19 November 2010

Organization: Maritime University of Szczecin, Faculty of Navigation & University of Natural Resources and Applied Life Sciences, Vienna, Department of Civil Engineering and Natural Hazards
Submission: Submission of abstract: May 2010, Submission of final paper: October 2010
Conference location: Maritime University of Szczecin, Poland
Conference Chairman: Prof. Lucjan Gucma
Audience: The conference is intended for civil and structural engineers and other professionals concerned with structures, systems or facilities that require the assessment of safety, risk and reliability. Participants could therefore be consultants, contractors, suppliers, owners, operators, insurance experts, authorities and those involved in research and teaching.

Further information:
Prof. Lucjan Gucma, Maritime University of Szczecin, Faculty of Navigation, Waly Chrobrego 1-2, 70-500 Szczecin, Poland.
E-mail: l.gucma@am.szczecin.pl
or

PD Dr.-Ing. Dirk Proske, University of Natural Resources and Applied Life Sciences, Vienna, Institute for Mountain Risk Engineering, Peter Jordan-Street 82, 1190 Wien, Austria
E-mail: dirk.proske@boku.ac.at

ESRA INFORMATION

1 ESRA Membership

1.1 National Chapters

- French Chapter
- German Chapter
- Italian Chapter
- Polish Chapter
- Portuguese Chapter
- Spanish Chapter
- UK Chapter

1.2 Professional Associations

- The Safety and Reliability Society, UK
- The Danish Society of Risk Assessment, Denmark
- ESRA Germany
- ESReDA
- French Institute for Mastering Risk, France (IMdR-SdF)
- SRE Scandinavia Reliability Engineers
- The Netherlands Society for Risk Analysis and Reliability (NVRB)
- Polish Safety & Reliability Association, Poland
- Asociación Española para la Calidad, Spain

1.3 Companies

- ARC Seibersdorf Research GmbH, Austria
- TAMROCK Voest Alpine, Austria
- IDA Kobenhavn, Denmark
- VTT Industrial Systems, Finland
- Bureau Veritas, France
- INRS, France
- Total, France
- Commissariat á l'Energie Atomique, France
- Eurocopter Deutschland GMbH, Germany
- GRS, Germany
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- IDEKO Technology Centre, Spain
- TECNUN, Spain
- TEKNIKER, Spain
- TNO Defence Research, The Netherlands
- BP International, UK
- HSE - Health & Safety Executive, UK
- Railway Safety, UK
- W.S. Atkins, UK

1.4 Educational and Research Institutions

- University of Innsbruck, Austria
- University of Natural Resources & Applied Life Sciences, Austria
- Université Libre de Bruxelles, Belgium
- University of Mining and Geology, Bulgaria
- Czech Technical University in Prague, Czech Republic
- Technical University of Ostrava, Czech Republic
- Technical University of Liberec, Czech Republic
- University of Defence, Czech Republic
- Tallin Technical University, Estonia
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- Politecnico di Torino, Italy
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- Universita Degli Studi di Pisa, Italy
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The Management Board is composed of the ESRA Officers plus one member from each country, elected by the direct members that constitute the National Chapters.

4 Standing Committees

4.1 Conference Standing Committee

Chairman: K. Kolowrocki, Gdynia Maritime University, Poland
The aim of this committee is to establish the general policy and format for the ESREL Conferences, building on the experience of past conferences, and to support the preparation of ongoing conferences. The members are one leading organiser in each of the ESREL Conferences.

4.2 Publications Standing Committee

Chairman: C. Guedes Soares, Instituto Superior Técnico, Portugal
This committee has the responsibility of interfacing with Publishers for the publication of Conference and Workshop proceedings, of interfacing with Reliability Engineering and System Safety, the ESRA Technical Journal, and of producing the ESRA Newsletter.

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ESRA is a non-profit international organization for the advance and application of safety and reliability technology in all areas of human endeavour. It is an "umbrella" organization with a membership consisting of national societies, industrial organizations and higher education institutions. The common interest is safety and reliability.
For more information about ESRA, visit our web page at http://www.esrahomepage.org.
For application for membership of ESRA, please contact the general secretary **Pieter van Gelder**, E-mail: P.van.Gelder@ct.tudelft.nl.
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