



# European Safety and Reliability Association

# Newsletter

<http://www.esrahomepage.org>

March 2016

## Editorial



*Terje Aven  
ESRA Chairman  
University of Stavanger, Norway*

Dear ESRA Colleagues,

Many of you have now submitted papers for the ESREL 2016 conference in Glasgow 25-29 September (<http://esrel2016.org>), the main event this year. Writing a scientific paper is hard work and it is usually a very good feeling to have come to the stage when it can be submitted.

Organising a conference of this size is also a lot of work, and I am pleased to see that the process is going fine. Our colleagues in Scotland are doing a great job.

ESRA has many technical committees (TCs) which support the ESREL conference by leading the paper reviewing process for the topics of the TC and which also organize specific seminars/webinars/etc in topics relevant for the TC. The last couple of months an updating of the scope of these committees have been conducted and several new Chairs and Co-chairs have been appointed. Initiatives have been taken to increase the number of relatively young Chairs. I am happy that we have succeeded in this and that the list of Chairs now also includes a substantially higher number of women. The current list of TCs and Chairs are presented elsewhere in this Newsletter. When the new website is soon launched, further details will be provided about the various TCs. I am grateful on behalf of ESRA for all the enthusiasm and energy shown in this updating process. There are indeed people out there who are willing to contribute to the development of our field. Thanks to all of you. New TCs have been

*ESRA Newsletter March 2016*

established for Resilience engineering, Economic analysis in risk management, and Security.

The first webinar was held 17 March 2016 (titled What is risk?), with close to 100 participants. I think we can say that it was an okay start for this ESRA webinar series. Watch for the announcement of the next webinar by Professor Enrico Zio: Challenges and opportunities in reliability engineering: the big KID (Knowledge, Information and Data).

Terje Aven  
Chairman of ESRA

---

## Feature Articles

---

### A Million Rare Events



*J. Robert Taylor,  
Emeritus Fellow affiliated to  
the Department of  
Management Engineering of  
the Technical University of  
Denmark*

There is no clear definition of what is a rare event, but in the field of accident studies, most of the events referred to are those with a frequency of about once per million years or less. So rare events should be rare? This would be true if there were only a few rare event possibilities. But what if there are a million possibilities? Then there should be one "rare" accident every year.

A refinery usually has between four and twenty process units. Each process unit has between zero and

five distillation columns, between two and ten large pumps, between zero and five vessels, up to about twenty heat exchangers, and may have some other main equipments such as compressors.

In reviewing ten professionally completed HAZOP studies for such units, the number of scenarios assessed was between 500 and 1200 scenarios per unit. Here the term “scenario” is used to mean a description with an initiating event and a set of safety barriers which must fail in order to cause a significant consequence event. Obviously the number of scenarios recorded in the HAZOP will depend on the degree of detail in the analysis. The level of detail in the HAZOPs studied were at the equipment failure mode level, such as “pressure regulator fails open” or “pipe leak”.

The average frequency of major hazard accidents per process unit around the world (actually in USA and Europe, because that is where systematic data are available) is between  $10^{-4}$  and  $4 \times 10^{-4}$  per unit year [see e.g. 1]. The average frequency per scenario in the HAZOP can therefore be estimated to be between about  $10^{-6}$  and  $10^{-7}$  per year. In other words, as a starting point, HAZOP is dealing quite well with rare events.

There are some major gaps in this optimistic picture:

- HAZOPs are never complete, the completeness typically varies between 75% and 95% of the accidents which could occur, as determined by HAZOP follow up studies using systematic lessons learned database, and by using HAZOP inter-comparisons [2].
- Large groups of major hazards types are routinely omitted from oil, gas and chemical HAZOPs and QRAs, notably those involving human error, those involving unusual physical effects such as condensation hammer, and those arising during maintenance.
- Most of the major accidents actually occurring arise in companies which do not make high quality HAZOPs or similar studies, or do not implement recommendations, as can be seen from the reports published by the US Chemical Safety Board [see e.g. 3].
- Several kinds of design error which are difficult to identify and prevent.

This last point is underlined by study of the Five Year Accident Histories made under the US Risk Management Programme [4]. There is a ratio of about 20 between the frequency of hazardous substance releases with offsite consequences between the best and worst performers, and about 20% of oil and gas installations had zero incidents. In other words some companies are doing much better than average. The best performing companies must be controlling risks from accidents at the level of  $10^{-9}$  per year for each scenario.

This result is actually a triumph for the principle of defence in depth. High integrity organisations focus on safety, allocation responsibility for safety barrier performance to individuals, setting performance

standards for barriers, developing key performance indices for barrier integrity.

Since the aim in most HAZOPs is to get the predicted scenario frequency down to about  $10^{-5}$  or  $10^{-6}$  per year, as evidenced by typical risk acceptance matrices, the risk is actually being controlled by other safety measures, such as good process safety management. The actual HAZOPs, HAZIDs and QRAs are not even coming close to describing the real safety issues which make the difference between a high integrity organisation and a run of the mill or poor performer. It is the care in barrier integrity which makes the difference.

It would be useful if we could include these safety management factors into our hazard identification and risk assessments. Safety management practices would then be supported by the assessments, and could be optimised for maximum safety. There have been several efforts to provide this [see e.g. 5].

One of the problems with HAZOP and QRA is that they do not deal well with accident prevention. Most recommendations arising concern mitigation. Modern safety management systems are often based on identification of safety critical equipments using HAZID. HAZIDs often make use of bow tie diagrams, marking all the safety barriers applicable to each threat on a diagram. These barriers are generally partial i.e. apply only to a fraction of the threats for which they are marked as needing protection. For example a typical threat is “internal corrosion”. There are many types of internal corrosion safety barriers. “Inspection” using ultrasonic testing can detect general and pitting corrosion, but generally not accelerated corrosion due to contamination with acid or use of incorrect materials, nor for crevice corrosion.

Deep HAZID was developed to overcome this problem [6]. This results in identification of about 150 threat types for pipes alone, each with its own set of safety barriers. If this approach is applied at the detail level for every scenario identified in HAZOP, the number of detailed scenarios per unit grows to about 100,000 scenarios with details both for prevention and mitigation.

We can go further than this. Failure of safety barriers generally requires that safety critical activities have failed. These failures arise through organisational failures. In order to investigate the possibilities for this, a catalogue of sociotechnical phenomena was built up and a model was developed safety critical functions [6]. This identified typically about five potential organisational failure modes for each safety barrier.

In all this results in an estimated half a million scenarios for a plant unit, or about five million scenarios for a complete refinery, analysed down to a level where technical and organisational measures can be taken to reduce risk. Each accident identified at this level is truly a rare event. Can we hope to be able to handle such a large number of detailed?

The solution to this problem, both in theory and in actual practice, is that preventive measures can be identified for typical groups of scenarios generically, and then applied as cause profiles for events identified for example by HAZOP. For example “loss of

containment” due to “resonant vibration fatigue” can be identified and judged to be relevant for pipes located near to compressors or large pumps and blowers. The organisational deficiencies of “no procedure for vibration inspection” and “no guidance for assessing vibration criticality” can then be identified (this is an actual example from a safety audit made using deep HAZID).

Both causes which result in barrier failure and those which cause barriers to be bypassed need to be identified. Sociotechnical causes which weaken or cause several safety barriers to fail (such as large backlogs in instrument testing) are particularly important.

Together with a risk assessed HAZOP study, the actual risk due to individual detailed technical and organisational causes can be assessed, simply by adding causal profiles to the events in a HAZOP analysis for example.

This approach to identifying rare events requires no changes to traditional safety audit procedures, but does provide it with an objective set of check lists and guidelines. The approach does take longer than traditional safety audits, simply because it finds more problems to be solved.

There may be other approaches to dealing with millions of rare events in a systematic way. Process systems provide one example where it is possible to deal with rare and very rare events. Process systems are a relatively easy case to deal with however. They may be complicated but they are only rarely complex. Also, their safety been studied intensely for over at least forty years, and there are tens of thousands of people doing detailed safety analysis around the world. It is important to find rare events methods which can be applied in other domains, particularly as we face major developments in technology, from ubiquitous communication and the internet of things, to working artificial intelligence, autonomous robots and drones, to autonomous vehicles. We cannot expect traditional techniques of FMEA and FTA alone to be adequate in addressing the millions of potential accident scenarios that these represent.

#### References

1. BP, Hazards of Oil Refining Distillation Units, I Chem E 2008
2. J.R.Taylor, Forty Years of HAZOP -Lessons Learned, Loss Prevention Bulletin, October 2012
3. CSB, INVESTIGATION REPORT Pesticide Chemical Runaway Reaction Pressure Vessel Explosion, US Chemical Safety Board Report No. 2008-08-I-WV, January 2011
4. Kleindorfer PR1, Belke JC, Elliott MR, Lee K, Lowe RA, Feldman HI, Accident epidemiology and the U.S. chemical industry: accident history and worst-case data from RMP\*Info, Risk Anal. 2003 Oct;23(5):865-81.
5. J.E.C. Williams, Management Assessment Guidelines in the Management of Risk, Technica Ltd. 1986

6. J.R.Taylor, Hazards, Threats and Barriers – hazards analysis to support safety management. ITSA.DK, 2015
7. J.T.Taylor, An Etiology of Sociotechnical Phenomena in Process Plant Operations, ITSA.DK, 2015

---

## PhD Degrees Completed

---

### A Holistic Framework of Degradation Modeling for Reliability Analysis and Maintenance Optimization of Nuclear Safety Systems



*Yanhui Lin  
Politecnico di Milano, Italy  
Supervisors: Prof. Enrico Zio*

Components of nuclear safety systems are in general highly reliable, which leads to a difficulty in modeling their degradation and failure behaviors due to the limited amount of data available. Besides, the complexity of such modeling task is increased by the fact that these systems are often subject to multiple competing degradation processes and that these can be dependent under certain circumstances, and influenced by a number of external factors (e.g. temperature, stress, mechanical shocks, etc.).

In this complicated problem setting, this PhD work aims to develop a holistic framework of models and computational methods for the reliability-based analysis and maintenance optimization of nuclear safety systems taking into account the available knowledge on the systems, degradation and failure behaviors, their dependencies, the external influencing factors and the associated uncertainties.

The original scientific contributions of the work are:

#### For single components:

Firstly, the multi-state physics model (MSPM) framework is extended to semi-Markov modeling to describe the fact that the time of transition to a state can depend on the residence time in the current state; this makes the framework more suitable to considering maintenance. Then, a general random shock model is proposed, where the probability of a random shock resulting in extreme or cumulative damage, and the cumulative damages, are both s-dependent on the current component degradation condition (the

component degradation state and residence time in that state). Finally, the random shock model is integrated into the MSPM framework to describe the influence of the shocks on the degradation processes. The results show that the proposed model is able to characterize the influences of different types of random shocks onto the component state probabilities and the reliability estimates.

**For small systems:**

- A piecewise-deterministic Markov process (PDMP) modeling framework is proposed to model multiple dependent competing degradation processes. The significance of the proposed method lies in its capability to describe the degradation dependency between physics-based models (PBMs), between multi-state models (MSMs) and between the two types of models.
- Epistemic uncertainty due to the incomplete or imprecise knowledge about the degradation processes is included in the PDMP modeling framework by describing the model parameters as fuzzy numbers and the finite-volume (FV) method is extended to calculate the system (fuzzy) reliability. The results show that the FV method can lead to comparable results as Monte Carlo (MC) simulation, but with reduced computation time.
- Mean absolute deviation (MAD) importance measure (IM) is extended to provide timely feedback on the criticality of a component in the PDMP modeling framework. The extended IM can effectively estimate the criticality of different components subject to multiple dependent discrete and continuous degradation processes, condition-based preventive maintenance (PM) via periodic inspections and corrective maintenance (CM).
- The Pareto optimal maintenance policies considering epistemic uncertainty and degradation dependency are derived by combining Non-dominated sorting differential evolution (NSDE), DE and FV. Epistemic uncertainty in the parameters of the model is taken into account by interval values, this leads to the formulation of a multi-objective optimization problem whose objectives are the lower and upper bounds of the expected maintenance cost. Given the Pareto front, the decision makers (DMs) can eventually choose the maintenance policy according to their preferences.
  - The PDMP modeling framework of (a) is extended for system reliability assessment, by considering the impacts of random shocks. The impacts of random shocks on the PBMs and MSMs at the same time can be characterized in different ways, due to the different nature of two types of degradation models. The dependencies between degradation processes and random shocks, and among degradation processes are addressed.

**For multi-component systems with larger size:**

A computational method combining binary decision diagrams (BDDs) and MC simulation is developed for the reliability assessment of systems with degradation dependency, to reduce computational costs. Firstly, a fault tree is transformed to a BDD from which all paths leading to the system failure or operation can be efficiently obtained. Secondly, MC simulation is used to estimate the probability of each path to compute the system reliability taking into account the dependencies between basic events. The results show that instead of modeling the degradation of the whole system by one PDMP, the proposed method can identify the groups of components being dependent and decompose the original PDMP into a group of smaller ones, which are independent from each other and easier to be solved. Besides, the states of these PDMPs leading to system failure can be easily obtained.

---

**RESS News**

---



*Carlos Guedes Soares  
Instituto Superior Técnico,  
Universidade de Lisboa*

The Reliability Engineering and System Safety (RESS) Journal has had a long association with ESRA, as shown in the Journal cover page. There have been a good number of ESRA members in the Editorial Board and among the authors of papers. Furthermore, RESS has published over the years special issues with selected papers from the ESREL Conferences.

The special issues dedicated to Conferences like ESREL normally have a set of papers of various topics and thus they are not different in nature from the normal Journal issues, which cover a variety of topics.

Recently a change in the policy of publishing special issues has been introduced, limiting them to well defined topics, so that the special issues are consistent in reflecting a given subject area.

To keep the contact with the ESREL Conferences, we will aim at identifying one or two main topics in each ESREL Conference which can be the focus of special issues. The special issues can draw much from the Conference but will not be limited to the extended versions of the papers presented at the Conference, hoping that other authors can also contribute to the topic.

Presently, some special issues are being prepared and announced on the Journal web page.

The Special Issue "Reliability and Performance of Multi-State Systems" is guest edited by Gregory

Levitin, from the Israel Electric Corp, Haifa, Israel; and Liudong Xing, from the University of Massachusetts, Dartmouth, USA. Its submission deadline is closing and papers are being reviewed.

The next Special Issue to open the submission date by June 2016 is the one on Complex Systems RAMS Optimization: Methods and Applications, which is Guest edited by David W. Coit from Rutgers University, Piscataway, NJ, USA and Enrico Zio from Centrale Supélec, Paris, France and Politecnico di Milano, Milan, Italy

We hope the Special Issues spark interest and attract quality papers.

---

## ESRA News

---

### New ESRA Technical Committees

#### Resilience Engineering

Chair:



*Ivonne Herrera*  
*SINTEF/NTNU*  
*Ivonne.A.Herrera@sintef.no*

Co-chair:



*Eric Rigaud*  
*MINES ParisTech*  
*eric.rigaud@mines-paristech.fr*

The objective of this Technical Committee is to promote and facilitate theoretical, empirical and practical research and innovations in the area of resilience engineering.

Resilience is gaining popularity, particularly with the increase of the possibility of situations in which systems, people and organizations have to interact, decide and act under high uncertainty, influenced by tempo of operations and socio-economic pressures.

Resilience Engineering is a research and practice area that covers theories, methods and practices to enable systems and organizations successful adjustment prior, during and after disturbances, changes and opportunities. Thus, enable the adaptive ability of systems and organizations in order to function effectively and safely.

Resilience engineering draws from a large number of foundation disciplines and closely related professional field. Different topics should be studied for actively contributing to understand and improve system's resilience. From models and methods for studying systems routines, practices, flexibility

improvisations and adjustments related capacities of adaptation to the development of operational methods and tools for supporting resilience development, performance assessment or change management. It also addresses design, governance and management of systems and organizations in an interdependent network. Moreover, interactions and cross-fertilisation between resilience engineering, other forms of resilience and other thematic of safety and reliability management need to be addressed.

Activities of the Committee will be the organization of creative sessions, innovation labs, technical sessions and roundtables at ESREL Conferences Committee.

#### Security

Chair:



*Sissel H. Jore*  
*University of Stavanger, Norway*  
*sissel.h.jore@uis.no*

Security can be defined as the ability to prepare for, adapt to, withstand and recover from dangers and crisis caused by deliberate, intentional, malicious acts of people, such as terrorism, sabotage, organized crime or hacking. Security includes assessing and reducing the likelihood and consequences of possible attacks with various types of risk reducing measures, for example critical infrastructure protection and by building organizational and societal resilience.

#### Economic analysis in risk management

Chair:



*Eirik B. Abrahamsen*  
*University of Stavanger, Norway*  
*eirik.b.abrahamsen@uis.no*

Economic analysis in risk management is a research field with special attention on economic analyses related to key topics in the field of risk management.

The objective of the Technical Committee is to improve the quality and usefulness of economic analyses to support decisions in risk management, as well as providing new knowledge, principles and methods for finding the right balance between different concerns, in particular safety for personnel and economic values.

Examples of topics addressed by the committee are:

- Portfolio theory in decision situations related to safety;
- Investments in safety on the basis of application of principles such as robustness, precaution and risk aversion;
- To what extent should the values be transformed into one comparable unit;
- Evaluation of the effectiveness of safety measures;

- Investments in safety measure and access to an insurance market.

The Technical Committee represents a scientific and technical forum for dialogue and exchange of ideas and knowledge among researchers within different areas of expertise, in particular economics and risk analysis and management.

## **CenCIP – A new center for Critical Infrastructure Protection research**

*Alexander Cedergren, Henrik Hassel, Jonas Johansson and Henrik Tehler*

*Division of Risk Management and Safety Engineering, Lund University, Sweden*

Centre for Critical Infrastructure Protection research (CenCIP) at Lund University, Sweden, is a newly inaugurated research center funded by the Swedish Civil Contingencies Agency (MSB). The center aims to conduct research focusing on how the functionality of critical infrastructures and societal functions can be maintained during normal operations and during crises. The research will address how risks and crises can be anticipated, how the systems and society can withstand and absorb stresses, and how critical functions can be resumed after an event. The center will address a broad set of critical infrastructures, including both “hard” systems such as electric power supply and transportation, as well as more “soft” systems such as health care and food supply. Furthermore, the center will also address how the work with critical infrastructure protection is affected by a number of ongoing trends.

The first of these trends are increased interdependencies between critical societal functions. This has to do with increased interconnectedness between different types of systems, i.e. health care systems depend strongly on information infrastructure. In addition, the geographical dependencies are also increasing where systems are interconnected over large geographical areas, i.e. the electric power system in Europe is in essence a single system. One of the implications of this is that disturbances can spread quickly across sectors and across geographical borders. Of course, there are also many positive sides of this development, such as increased effectiveness; however, at the same time the complexity is growing, as is the challenges for anticipating the behavior of these system-of-systems.

The second of these trends are increased fragmentation of the responsibilities of critical infrastructures. More specifically, this has to do with the fact that the planning, operations and maintenance of these systems are distributed across an increasing number of private and public actors. To a large extent it is the societal trends of privatizations and deregulations that have led to this development. Again, the increased fragmentation has positive sides in terms of e.g. increased flexibility and increased competition, which can lead to increased effectiveness. However, as

these responsibilities are increasingly fragmented, challenges may also arise in terms of barriers for information sharing, coordination, etc. which may affect the risk management of the critical infrastructures.

Taken together these two trends act in opposite directions. The increased interdependencies require increased ability to coordinate activities, to share information and to obtain an overview of the function of these system-of-systems. With increased fragmentation, on the other hand, there is an increased risk of creating “silos”, i.e. a situation in which the actors focus primarily on their “own” systems and objectives giving little attention to the interaction with surrounding systems. That in turn could lead to difficulties in identifying and addressing risks and vulnerabilities that exist across boundaries as well as to prioritize measures and changes.

The changes to the operation of critical infrastructures require new ways of working with risk, crisis and continuity management. The research conducted in CenCIP aims to develop knowledge, approaches and methods that can be used to better manage these challenges in order to increase functionality and resiliency of these systems.

The research in CenCIP will be organized around three overlapping themes: 1), Analysis of interdependencies and societal consequences due to infrastructure disturbances, 2) concepts and methods and the role of CIP for crisis management in society 3) governance, measurement and learning. In the research center initially 10 researchers will be involved, with the ambition to continue growing. The researchers have expertise in risk and safety management, electrical engineering, geographic information systems, strategic communications and logistics.

More information can be found at the website of the research center: <http://www.cencip.lu.se>.

---

## **Calendar of Safety and Reliability Events**

---

**2016 International Applied Reliability Symposium Europe (2016 ARS Europe)**  
**Munich, Germany**  
**4th-6th April 2016**

The 2016 ARS Europe will be held April 4 - 6, 2016 in Munich, Germany. This year, a third track focused on durability and fatigue is offered alongside two full tracks of reliability and maintainability presentations.

ARS provides a unique forum for engineers and managers to gain insights from results-oriented presentations and tutorials, network with industry professionals and explore solutions from knowledgeable service providers.

Important dates:

- October 30, 2015 – Submit proposals

Conference website:

<http://www.arsymposium.org/europe/index.htm>

**35th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2016)  
Symposium on Structures, Safety and Reliability  
Busan, South Korea  
19th-24th June 2016**

Since 2003, the OMAE conference has more than tripled in size, with over 1,000 participants at OMAE 2015 in St. John's, Canada. We expect to set a new OMAE attendance record in Busan with the goal of exceeding 1,500 participants.

The annual OMAE conference is an international assembly of engineers, researchers, technical specialists and students in the fields of ocean, offshore and arctic engineering. It is an opportunity to meet and present advances in technology and its scientific support, exchange ideas and experiences whilst promoting technological progress and its application in industry and promote international cooperation in ocean, offshore and arctic engineering.

Call for papers - Authors should submit a title/abstract to begin the paper submission process. Prior to the date noted below, authors should then submit full-length manuscripts for peer review. Draft manuscripts and final-paper submissions must conform to ASME publication guidelines.

Important dates:

- December 14, 2015 – Deadline for Abstract Submission
- January 4, 2016 – Full-Length Draft Paper Due
- February 22, 2016 – Notification of Acceptance/Rejection
- March 21, 2016 – Final Paper Due

Conference Website: <http://www.omae2016.com>

**6th International Conference on Accelerated Life Testing and Degradation models (ALT 2016)**

Troyes, France

22th-24th June 2016

ALT'2016 is the 6th international conference concerned with the latest scientific results and applications in reliability testing and analysis. The aim of the conference is to bring researchers and practitioners from universities, institutions and industries, together to present and discuss innovative methodologies and practical applications in the reliability field: assessment, modeling, testing, analysis, design and optimization. Theoretical issues and applied case studies will range from academic considerations to industrial, medical, and social applications. There will be invited talks, plenary and parallel sessions. Accepted papers will be published in the conference proceedings.

All the previous editions were in France: Angers (2006), Bordeaux (2008), Clermont-Ferrand (2010), Rennes (2012) and Pau (2014).

Based on the previous editions, around 5 half-days are planned for the talks. Each day will start and close by plenary invited talks. Between, there will be an alternate of parallel sessions and plenary invited talks. Thus, the program should include around 40 talks set as follows:

- 11 plenary invited talks (45 minutes);
- around 30 short talks (20 minutes) in the parallel sessions.

Registration fees are fixed to 300 euros, except for PhD students (100 euros). The planned budget is based on the registration of 30 participants at the full rate and 15 at the reduced rate. For the invited speakers, registration fees and hotels will be covered, and apart of the trip (up to 550 euros for now). The participation of young researchers/professors and PhD students will be promoted through low registration fees. The total number of participants is expected to be around 60 and 70.

Important dates:

- January 31, 2016 – One page abstract submission deadline
- March 15, 2016 – Notification acceptance/rejection
- May 15, 2016 – Full paper submission deadline

Conference Website: <http://alt2016.sciencesconf.org>

## **The International Conference on Information and Digital Technologies 2016 (IDT 2016)**

Rzeszów, Poland

5th-7th July 2016

The International Conference IDT'2016 is next Conference after the International Conference on Digital Technologies that was held in Zilina traditionally. The aim of the conference is to bring together researches, developers, teachers from academy as well as industry working in all areas of information technologies. Young researchers and postgraduate PhD students are greatly welcome to participate in this event. Beside the scientific field, several cultural and social events are planned for the enjoyment of conference attendees. The proceedings of IDT 2015 was indexed by IEEE Xplore and Scopus.

Prospective authors are requested to send a paper (maximum 12 pages including figures, tables and references) for review by the Scientific Program Committee. All submissions must be written in English, starting with a succinct statement of the problem, the results achieved, their significance and comparison with previous works (if any), as well as a list of references. The submissions should also include: title of the proposed paper, authors names, affiliations, addresses, name of an author to contact for correspondence, e-mail address of the contact author, topics which best describe the paper. Paper should be submitted electronically.

Accepted papers will be published in conference proceedings (CD-version under an ISBN reference). All submitted papers will be reviewed by Program Committee members.

In an attempt to promote the dissemination of recent industrial developments and the interaction between industry and academia, IDT 2016 will encourage the submission of industry oriented technical applications. These special contributions will be submitted and published in a format that includes a maximum 1-page of abstract. The evaluation of these contributions will address the innovation/originality of the industrial application, the quality of presentation and the technical interest to the community working in that field.

### Important dates:

- April 24, 2016 – Full paper submission
- May 23, 2016 – Paper acceptance notification
- June 10, 2016 – Camera-ready papers
- June 20, 2016 – Final program

Conference website: <http://idt.fri.uniza.sk>

## **2016 International Conference on Quality, Reliability, Risk, Maintenance and Safety Engineering (QR2MSE 2016)**

Jiuzhaigou, Sichuan, China

25th-28th July 2016

QR2MSE 2016 & WCEAM 2016 is an international forum for exchange of innovative ideas, cutting-edge research results, and applications of asset management, reliability and quality tools in design, manufacturing, and operation and maintenance of engineering systems. Papers dealing with case studies, reliability data generation, experimental results, best design practice, and effective asset management solutions are of particular interest. All papers accepted will be included in the conference proceedings. Selected peer reviewed papers will be published in Springer's ebook proceedings and international journals indexed by Thomson Reuters Web of Science (SCI) or Engineering Village (EI Compendex).

### Topics of Interests:

- Strategic asset management
- Prognostics and health management
- Asset fleet management
- Condition based maintenance
- Quality engineering
- Quality assurance and cost issues
- Experimental design for quality control
- Total quality management techniques
- Reliability theory and application
- Product reliability and safety evaluation
- Reliability testing and statistics
- Structural reliability
- Equipment management and maintenance
- e-Maintenance
- Maintenance support modeling and simulation
- Reliability centered maintenance
- Novel technologies for maintenance: robotics, virtual reality and additive manufacturing
- Life cycle management and services
- Systems integrity management
- Software reliability and testing
- Reliability tools for product development
- Risk management
- Physics of Failure
- Inspection
- Advanced sensor technologies
- Condition monitoring, diagnostics and prognostics
- System health and analytics
- Contractor logistics theory and practice
- Optimal design
- Multidisciplinary design optimization
- Human and organisational factors
- Applications of industrial internet
- Supply chain management
- Standardisation
- Information management



Submission of papers - Extended abstract or full papers should be submitted electronically in MS-Word via [icqrms@uestc.edu.cn](mailto:icqrms@uestc.edu.cn) by March 10, 2016. Authors' names, affiliations, and contact information must be included in submission.

Important dates:

- Mar 10, 2016 – Full Paper Submission Deadline
- Apr 10, 2016 – Full Paper Acceptance Notification
- Apr 30, 2016 – Camera Ready Papers Due

Conference website: <http://www.qr2mse.org>

## **The 35th International Conference on Computer Safety, Reliability and Security (SafeComp 2016)**

Trondheim, Norway

20th-23th September 2016

Since it was established in 1979 by the European Workshop on Industrial Computer Systems, Technical Committee 7 on Reliability, Safety and Security (EWICS TC7), SAFECOMP has contributed to the progress of the state-of-the-art in dependable application of computers in safety-related and safety-critical systems. SAFECOMP is an annual event covering the state-of-the-art, experience and new trends in the areas of safety, security and reliability of critical computer applications.

SAFECOMP provides ample opportunity to exchange insights and experience on emerging methods, approaches and practical solutions. It is a single track conference without parallel sessions, allowing easy networking.

The conference covers all aspects related to the development, assessment, operation and maintenance of safety-related and safety-critical computer systems.

Important dates:

- February 1, 2016 – Workshop proposal submission
- March 4, 2016 – Full paper submission
- May 6, 2016 – Notification of acceptance
- June 13, 2016 – Fast Abstract submission
- September 20, 2016 – Workshops
- September 21-23, 2016 – Conference

Conference website: <http://ntnu.edu/safecomp2016>

## **35th Symposium on Reliable Distributed Systems (SRDS)**

Budapest, Hungary

26th-29th September 2016

The 35th Symposium on Reliable Distributed Systems (SRDS 2016) plans to run pre-conference

workshops (half-day or full-day) on September 26th, 2016, similarly to what happened in previous editions of the conference. Researchers interested in organizing a workshop on topics related to reliable distributed systems are invited to submit workshop proposals.

The proposals shall be submitted via e-mail to the SRDS 2016 Workshop Co-chairs:

- Sanjay Madria, Missouri University of Science and Technology, USA - [madrias@mst.edu](mailto:madrias@mst.edu)
- Miguel Correia, INESC-ID, Instituto Superior Técnico, Portugal – [miguel.p.correia@tecnico.ulisboa.pt](mailto:miguel.p.correia@tecnico.ulisboa.pt)

Important dates:

- February 28, 2016 – Workshop proposals
- March 4, 2016 – Notification of acceptance
- September 26, 2016 – Workshop day

Conference website: <http://srds2016.inf.mit.bme.hu>

## **14th International Probabilistic Workshop (IPW 2016)**

Ghent, Belgium

5th-7th December 2016

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.

Important dates:

- April 1, 2016 – Submission of abstracts
- July 1, 2016 – Submission of full papers

Conference website: <http://www.ipw2016.ugent.be>

---

## **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
- Danish Society of Risk Assessment, Denmark

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

### 1.3 Companies

- TAMROCK Voest Alpine, Austria
- IDA Kobenhavn, Denmark
- VTT Industrial Systems, Finland
- Bureau Veritas, France
- INRS, France
- Total, France
- Commissariat à l'Energie Atomique, France
- DNV, France
- Eurocopter Deutschland GmbH, Germany
- GRS, Germany
- SICURO, Greece
- VEIKI Inst. Electric Power Res. Co., Hungary
- Autostrade, S.p.A, Italy
- D'Appolonia, S.p.A, Italy
- IB Informatica, Italy
- RINA, Italy
- TECSA, SpA, Italy
- TNO Defence Research, The Netherlands
- Dovre Safetec Nordic AS, Norway
- PRIO, Norway
- SINTEF Industrial Management, Norway
- Central Mining Institute, Poland
- Adubos de Portugal, Portugal
- Transgás - Sociedade Portuguesa de Gás Natural, Portugal
- Cia. Portuguesa de Produção Electrica, Portugal
- Siemens SA Power, Portugal
- ESM Res. Inst. Safety & Human Factors, Spain
- IDEKO Technology Centre, Spain
- TECNUN, Spain
- TEKNIKER, Spain
- CSIC, Spain
- HSE - Health & Safety Executive, UK
- Atkins Rails, UK
- W.S. Atkins, UK
- Railway Safety, UK
- Vega Systems, UK

### 1.4 Educational and Research Institutions

- University of Innsbruck, Austria
- University of Natural Resources & Applied Life Sciences, Austria
- AIT Austrian Institute of Techn. GmbH, Austria
- Université Libre de Bruxelles, Belgium
- University of Mining and Geology, Bulgaria
- Czech Technical Univ. in Prague, Czech Republic
- Technical University of Ostrava, Czech Republic
- University of Defence, Czech Republic
- Tallin Technical University, Estonia
- Helsinki University of Technology, Finland
- École de Mines de Nantes, France
- Université Henri Poincaré (UHP), France

- Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS), France
- Université de Bordeaux, France
- Université de Technologie de Troyes, France
- Université de Marne-la-Vallée, France
- INERIS, France
- Fern University, Germany
- Technische Universität Muenchen, Germany
- Technische Universität Wuppertal, Germany
- University of Kassel, Germany
- TU Braunschweig, Germany
- Institute of Nuclear Technology Radiation Protection, Greece
- University of the Aegean, Greece
- Università di Bologna (DICMA), Italy
- Politecnico di Milano, Italy
- Politecnico di Torino, Italy
- Università Degli Studi di Pavia, Italy
- Università Degli Studi di Pisa, Italy
- Technical University of Delft, The Netherlands
- Institute for Energy Technology, Norway
- Norwegian Univ. Science & Technology, Norway
- University of Stavanger, Norway
- Technical University of Gdansk, Poland
- Gdynia Maritime Academy, Poland
- Institute of Fundamental Techn. Research, Poland
- Technical University of Wroclaw, Poland
- Instituto Superior Técnico, Portugal
- Universidade de Coimbra, Portugal
- Universidade Nova de Lisboa - FCT, Portugal
- Universidade de Minho, Portugal
- Universidade do Porto, Portugal
- University Politechnica of Bucharest, Romania
- University of Iasi, Romania
- Slovak Academy of Sciences, Slovakia
- University of Trencin, Slovakia
- Institute "Jozef Stefan", Slovenia
- Asociación Española para la Calidad, Spain
- PMM Institute for Learning, Spain
- Universidad D. Carlos III de Madrid, Spain
- Universidad de Extremadura, Spain
- Univ. de Las Palmas de Gran Canaria, Spain
- Universidad Politecnica de Madrid, Spain
- Universidad Politecnica de Valencia, Spain
- Institute de Matematica y Fisica Fundamental (IMAFF), Spain
- University of Castilla-La Mancha, Spain
- Luleå University, Sweden
- World Maritime University, Sweden
- Institut f. Energietechnik (ETH), Switzerland
- Paul Scherrer Institut, Switzerland
- City University London, UK
- Liverpool John Moores University, UK
- University of Aberdeen, UK
- University of Bradford, UK
- University of Salford, UK
- University of Strathclyde, Scotland, UK

### 1.5 Associate Members

- Federal University of Pernambuco, Brazil
- Fluminense Federal University, Brazil
- Pontifícia Universidade Católica, Brazil
- European Commission - DR TREN (Transport and Energy), in Luxembourg
- Vestel Electronics Co., Turkey

## 2. ESRA Officers

### Chairman

Terje Aven (terje.aven@uis.no)  
University of Stavanger, Norway

### Vice-Chairman

Radim Bris (radim.bris@vsb.cz)  
Technical University of Ostrava, Czech Republic

### General Secretary

Coen van Gulijk (C.VanGulijk@hud.ac.uk)  
University of Huddersfield, UK

### Treasurer

Piero Baraldi (Piero.baraldi@polimi.it)  
Politecnico di Milano, Italy

### Past Chairman

Enrico Zio (enrico.zio@polimi.it)  
Politecnico di Milano, Italy

### Chairmen of the Standing Committees

Antoine Grall, University of Technology of Troyes, France  
C. Guedes Soares, Instituto Superior Técnico, Portugal

## 3. Standing Committees

### 3.1 Conference Standing Committee

Chairman: A. Grall, University of Tech. of Troyes, France  
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.

### 3.2 Publications Standing Committee

Chairman: C. Guedes Soares, Instituto Sup. 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.

## 4. Technical Committees

### Methodologies

#### 4.1 Accident and Incident modeling

Chairman: Stig Johnsen, Norway & Nicola Paltrinieri, Norway  
E-mail: Stig.O.Johnsen@sintef.no;  
nicola.paltrinieri@ntnu.no

#### 4.2 Economic Analysis in Risk Management

Chairman: Eirik B. Abrahamsen, Norway  
E-mail: eirik.b.abrahamsen@uis.no

#### 4.3 Foundational Issues in Risk Assessment and Management

Chairman: Terje Aven, Norway & Enrico Zio, France  
E-mail: terje.aven@uis.no; enrico.zio@ecp.fr

#### 4.4 Human Factors and Human Reliability

Chairman: Luca Podofillini, Switzerland & Chiara Leva, Ireland  
E-mail: luca.podofillini@psi.ch; levac@tcd.ie

#### 4.5 Maintenance Modeling and Applications

Chairman: Christophe Bérenguer, France & Mitra Fouladirad, France  
E-mail: christophe.berenguer@grenoble-inp.fr;  
mitra.fouladirad@utt.fr

#### 4.6 Mathematical Methods in Reliability and Safety

Chairman: John Andrews, UK & Nicolae Brinzei, France

E-mail: John.Andrews@nottingham.ac.uk;  
nicolae.brinzei@univ-lorraine.fr

#### 4.7 Prognostics and System Health Management

Chairman: Piero Baraldi, Italy & Enrico Zio, France  
E-mail: piero.baraldi@polimi.it; enrico.zio@ecp.fr

#### 4.8 Resilience Engineering

Chairman: Ivonne Herrera, Norway & Eric Rigaud, France  
E-mail: Ivonne.A.Herrera@sintef.no;  
eric.rigaud@mines-paristech.fr

#### 4.9 Risk assessment

Chairman: Marko Cepin, Slovenia & Henrik Hassel, Sweden  
E-mail: marko.cepin@fe.uni-lj.si;  
henrik.hassel@risk.lth.se

#### 4.10 Risk Management

Chairman: Lesley Walls, UK & David Valis, Czech Republic & Marcelo Hazin, Brazil  
E-mail: lesley@mansci.strath.ac.uk;  
david.valis@unob.cz; [marcelohazin@gmail.com](mailto:marcelohazin@gmail.com)

#### 4.11 Simulation for Safety and Reliability Analysis

Chairman: Nicola Pedroni, France & Edoardo Patelli, UK  
E-mail: nicola.pedroni@ecp.fr;  
edoardo.patelli@liverpool.ac.uk

#### 4.12 Structural Reliability

Chairman: Jana Markova, Czech Republic & Martin Krejsa, Czech Republic  
E-mail: jana.markova@klok.cvut.cz;  
martin.krejsa@vsb.cz

#### 4.13 System Reliability

Chairman: Gregory Levitin, Israel & Serkan Eryilmaz, Turkey  
E-mail: gregory.levitin@iec.co.il;  
serkan.eryilmaz@atilim.edu.tr

#### 4.14 Uncertainty analysis

Chairman: Emanuele Borgonovo, Italy & Roger Flage, Norway  
E-mail: emanuele.borgonovo@unibocconi.it;  
roger.flage@uis.no

## Application Areas - Technological Sectors

#### 4.15 Aeronautics and Aerospace

Chairman: Darren Prescott, UK  
E-mail: darren.prescott@nottingham.ac.uk

#### 4.16 Chemical and Process Industry

Chairman: Valerio Cozzani, Italy & Gabriele Landucci, Italy & Nima Khakzad, The Netherlands  
E-mail: valerio.cozzani@unibo.it;  
gabriele.landucci@unipi.it; nkhakzad@gmail.com

#### 4.17 Civil Engineering

Chairman: Raphael Steenbergen, The Netherlands  
E-mail: raphael.steenbergen@tno.nl

#### 4.18 Critical Infrastructures

Chairman: Giovanni Sansavini, Switzerland & Enrico Zio, France  
E-mail: sansavini@ethz.ch; enrico.zio@ecp.fr

#### 4.19 Energy

Chairman: Michalis Christou, Belgium  
E-mail: Michalis.Christou@ec.europa.eu

#### 4.20 Information Technology and Telecommunications

Chairman: Elena Zaitseva, Slovakia & Ralf Mock, Switzerland  
E-mail: elena.zaitseva@fri.uniza.sk;  
[ralf.mock@zhaw.ch](mailto:ralf.mock@zhaw.ch)

#### 4.21 Land Transportation

Chairman: Olga Fink, Switzerland & Bob Huisman, The Netherlands  
E-mail: [olga.fink@ivt.baug.ethz.ch](mailto:olga.fink@ivt.baug.ethz.ch);  
[b.huisman@nedtrain.nl](mailto:b.huisman@nedtrain.nl)

#### 4.22 Manufacturing

Chairman: Benoit Iung, France & François Peres, France  
E-mail: [benoit.iung@univ-lorraine.fr](mailto:benoit.iung@univ-lorraine.fr);  
[francois.peres@enit.fr](mailto:francois.peres@enit.fr)

#### 4.23 Maritime and Offshore technology

Chairman: Jin Wang, UK & Ingrid B. Utne, Norway & Mario Brito, UK  
E-mail: [j.wang@ljmu.ac.uk](mailto:j.wang@ljmu.ac.uk); [ingrid.b.utne@ntnu.no](mailto:ingrid.b.utne@ntnu.no);  
[M.P.Brito@soton.ac.uk](mailto:M.P.Brito@soton.ac.uk)

#### 4.24 Natural Hazards

Chairman: Pieter van Gelder, The Netherlands & Bas Kolen, The Netherlands  
E-mail: [p.h.a.j.m.vangelder@tudelft.nl](mailto:p.h.a.j.m.vangelder@tudelft.nl);  
[B.Kolen@tudelft.nl](mailto:B.Kolen@tudelft.nl)

#### 4.25 Nuclear Industry

Chairman: Sebastian Martorell, Spain & Francesco Di Maio, Italy  
E-mail: [smartore@iqn.upv.es](mailto:smartore@iqn.upv.es);  
[francesco.dimaio@polimi.it](mailto:francesco.dimaio@polimi.it)

#### 4.26 Occupational Safety

Chairman: Ben Ale, The Netherlands & Reniers Genserik, Belgium  
E-mail: [ben.ale@xs4all.nl](mailto:ben.ale@xs4all.nl);  
[genserik.reniers@uantwerpen.be](mailto:genserik.reniers@uantwerpen.be)

#### 4.27 Security

Chairman: Sissel H. Jore, Norway  
E-mail: [sissel.h.jore@uis.no](mailto:sissel.h.jore@uis.no)



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 Coen van Gulijk E-mail: [c.vangulijk@hud.ac.uk](mailto:c.vangulijk@hud.ac.uk).

Please submit information to the ESRA Newsletter to any member of the Editorial Board:

Editor: Carlos Guedes Soares – [c.guedes.soares@tecnico.ulisboa.pt](mailto:c.guedes.soares@tecnico.ulisboa.pt)  
Instituto Superior Técnico, Lisbon

#### Editorial Board:

**Ángelo Teixeira** – [angelo.teixeira@tecnico.ulisboa.pt](mailto:angelo.teixeira@tecnico.ulisboa.pt)

Instituto Superior Técnico, Portugal

**Antoine Grall** – [antoine.grall@utt.fr](mailto:antoine.grall@utt.fr)

University of Technology of Troyes, France

**Dirk Proske** – [dirk.proske@boku.ac.at](mailto:dirk.proske@boku.ac.at)

University of Natural Resources and

Applied Life Sciences, Austria

**Giovanni Uguccioni** – [giovanni.uguccioni@dappolonia.it](mailto:giovanni.uguccioni@dappolonia.it)

D'Appolonia S.p.A., Italy

**Igor Kozine** – [igko@dtu.dk](mailto:igko@dtu.dk)

Technical University of Denmark, Denmark

**Sylwia Werbinska** – [sylwia.werbinska@pwr.wroc.pl](mailto:sylwia.werbinska@pwr.wroc.pl)

Wroclaw University of Technology, Poland

**Eirik Albrechtsen** – [eirik.albrechtsen@iot.ntnu.no](mailto:eirik.albrechtsen@iot.ntnu.no)

Norwegian University of Science Technology, Norway

**Luca Podofilini** – [luca.podofilini@psi.ch](mailto:luca.podofilini@psi.ch)

Paul Scherrer Institut, Switzerland

**Marko Cepin** – [marko.cepin@fe.uni-lj.si](mailto:marko.cepin@fe.uni-lj.si)

University of Ljubljana, Slovenia

**Paul Ulmeanu** – [paul@cce.fiab.pub.ro](mailto:paul@cce.fiab.pub.ro)

Univ. Politehnica of Bucharest, Romania

**Radim Bris** – [radim.bris@vsb.cz](mailto:radim.bris@vsb.cz)

Technical University of Ostrava, Czech Republic

**Sebastián Martorell** – [smartore@iqn.upv.es](mailto:smartore@iqn.upv.es)

Universidad Politécnica de Valencia, Spain

**Joël Luyk** – [j.luyk@delta-pi.nl](mailto:j.luyk@delta-pi.nl)

The Netherlands Soc. for Risk Analysis & Reliability

**Uday Kumar** – [uday.kumar@ltu.se](mailto:uday.kumar@ltu.se)

Luleå University of Technology, Sweden

**Zoe Nivolianitou** – [zoe@ipta.demokritos.gr](mailto:zoe@ipta.demokritos.gr)

Demokritos Institute, Greece

**Zoltan Sadovsky** – [zoltan@sadovsky.info](mailto:zoltan@sadovsky.info)

USTARCH, SAV, Slovakia