

# Quantitative Approach to Safety Assessment of the Railway Interlocking System

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## Abstract

The paper deals with a quantitative approach to safety assessment process applicable to the safety-related systems, specially the railway interlocking one. The authors present the methodology based on the Failure Mode and Effects Analysis (FMEA) and the Fault Tree Analysis (FTA) that is applicable to performing safety analysis of both electronic and computer based systems. The mathematical basis for the FTA is detailed, with a special attention paid to the mechanisms used to determine probability of hazardous events based on primary event occurrence. For the sake of better understanding examples of Markov's graphs for a different number of simultaneous hazardous faults are given. Relation between the presented approach and European Standards is indicated.

## 1. Introduction

The railway interlocking system is a special kind of control system that in addition to control functions must also

involve safety-related functions. Safety is considered to be a basic property inherent to such kind of systems. There is necessity to build a model describing transition of an interlocking system from failure-free (safe) mode to failure involved (potentially hazardous) mode as a consequence of random external influences in the process of system ageing. For the sake of introduction, let's give some ideas on such a model.

External influences can generally be characterised as the  $n$ -dimensional random process with time-dependent random quantities (temperature, voltage, electromagnetic interference etc.) of the  $n$ -dimensional random vector. Analysis of influences of this random process on operation of the interlocking system is possible only if its marginal, coupling and conditional characteristics are known. It is a complex task of mathematical statistics.

On the base of data analysis the process must be identified and its prognosis performed for the whole useful life of the interlocking system. In addition, external influences on the interlocking system depend on particular operation environment (i.e. on local conditions). It is unthinkable (for time and financial reasons) to perform the overall analysis of external influences on system safety individually for any operation environment. For the practical use it is acceptable if system requirements specification defines limit values for monitored random variables and in the interlocking system design there are used such technological and circuit solutions (barriers) that enable to omit (fully or partially) external influences. Operation environment of a system must be chosen in accordance with system requirements specification. This solution will also exclude possible

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Computer Science and Information Technologies  
CSIT'2000  
Ufa, Russia, 2000

# Safety Assessment A Quantitative Approach

**Douglas M. Henderson FSA, CBCP**



## **Safety Assessment A Quantitative Approach:**

**Safety Assessment** B.S. Dhillon, Abdul Raouf, S.I., 1993-10-13 Over the years there have been several books and hundreds of articles and reports on safety with more than three dozen journals and newsletters in English alone on this subject Unlike other books however Safety Assessment gathers together vital information and presents a unified approach to current quantitative safety assessment Previous knowledge of this subject is not necessary since two chapters on introductory material are provided to give sufficient background All chapters discuss topics of current interest This book is excellent as a text for elective courses on safety for science business and engineering students It is also an indispensable guide for engineers and professionals in industrial ergonomics operations management and production

**Offshore Risk Assessment Vol. 1** Jan-Erik Vinnem, Willy Røed, 2019-09-11 This is the first textbook to address quantified risk assessment QRA as specifically applied to offshore installations and operations As the first part of the two volume updated and expanded fourth edition it adds a new focus on the EU Offshore Safety Directive and discusses the new perspective on risk from the Norwegian Petroleum Safety Authority followed by new and updated international standards New safety statistics for the Norwegian sectors are presented as well as new case studies on international offshore accidents such as the explosion on FPSO Sao Mateus in 2015 which involved 9 fatalities Separate chapters analyse the main hazards for offshore structures fire explosion collision and falling objects as well as structural and marine hazards Risk mitigation and control are discussed as well as how the results of quantitative risk assessment studies should be presented The fourth edition presents updated hydrocarbon release statistics together with new methods for modelling the risk from ignited hydrocarbon releases There have been recent advances in the modelling of collision risk from passing and attending vessels based on extensive research these advances are described in detail in addition to new developments in the safety of Dynamic Positioning vessels In closing the book provides updated statistics and lessons learned from accidents involving offshore helicopter transportation of personnel The book offers a comprehensive reference guide for academics and students of marine offshore risk assessment and management It will also be of interest to professionals in the industry as well as contractors suppliers consultants and regulatory authorities

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Human and Ecological Risk Assessment Dennis J. Paustenbach, 2024-04-15 Understand the fundamentals of human risk assessment with this introduction and reference Human risk assessments are a precondition for virtually all industrial action or environmental regulation all the more essential in a world where chemical and environmental hazards are becoming more abundant These documents catalog potential environmental toxicological ecological or other harms resulting from a particular hazard from chemical spills to construction projects to dangerous workplaces They turn on a number of variables of which the most significant is the degree of human exposure to the hazardous agent or process Human and Ecological Risk Assessment combines the virtues of a textbook and reference work to introduce and analyze these vital documents Beginning with the foundational theory of human health risk assessment it then supplies case studies and detailed analysis illustrating the practice of producing risk assessment documents Fully updated and authored by leading authorities in the field the result is an indispensable work Readers of the second edition of Human and Ecological Risk Assessment will also find Over 40 entirely new case studies reflecting the latest in risk assessment practice Detailed discussion of hazards including air emissions contaminated food and soil hazardous waste sites and many more Case studies from multiple countries to reflect diverse international standards Human and Ecological Risk Assessment is ideal for professionals and advanced graduate students in toxicology industrial hygiene occupational medicine environmental science and all related subjects

*Microbiological risk assessment guidance for food* , 2021-06-07

**Knowledge in Risk Assessment and Management** Terje Aven, Enrico Zio, 2018-02-20 Exciting new developments in risk assessment and management Risk assessment and management is fundamentally founded on the knowledge available on the system or process under consideration While this may be self evident to the laymen thought leaders within the risk community have come to recognize and emphasize the need to explicitly incorporate knowledge K in a systematic rigorous and transparent framework for describing and modeling risk Featuring contributions by an international team of researchers and respected practitioners in the field this book explores the latest developments in the ongoing effort to use risk assessment as a means for characterizing knowledge and or lack of knowledge about a system or process of interest By offering a fresh perspective on risk assessment and management the book represents a significant contribution to the development of a sturdier foundation

for the practice of risk assessment and for risk informed decision making How should K be described and evaluated in risk assessment How can it be reflected and taken into account in formulating risk management strategies With the help of numerous case studies and real world examples this book answers these and other critical questions at the heart of modern risk assessment while identifying many practical challenges associated with this explicit framework This book written by international scholars and leaders in the field and edited to make coverage both conceptually advanced and highly accessible Offers a systematic rigorous and transparent perspective and framework on risk assessment and management explicitly strengthening the links between knowledge and risk Clearly and concisely introduces the key risk concepts at the foundation of risk assessment and management Features numerous cases and real world examples many of which focused on various engineering applications across an array of industries Knowledge of Risk Assessment and Management is a must read for risk assessment and management professionals as well as graduate students researchers and educators in the field It is also of interest to policy makers and business people who are eager to gain a better understanding of the foundations and boundaries of risk assessment and how its outcomes should be used for decision making

**The Security Risk Assessment Handbook** Douglas Landoll, 2016-04-19 The Security Risk Assessment Handbook A Complete Guide for Performing Security Risk Assessments provides detailed insight into precisely how to conduct an information security risk assessment Designed for security professionals and their customers who want a more in depth understanding of the risk assessment process this volume contains real wor

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*Uncertainty in Risk Assessment* Terje Aven, Piero Baraldi, Roger Flage, Enrico Zio, 2014-02-03 Explores methods for the representation and treatment of uncertainty in risk assessment In providing guidance for practical decision making situations concerning high consequence technologies e g nuclear oil and gas transport etc the theories and methods studied in *Uncertainty in Risk Assessment* have wide ranging applications from engineering and medicine to environmental impacts and natural disasters security and financial risk management The main focus however is on engineering applications While requiring some fundamental background in risk assessment as well as a basic knowledge of probability theory and statistics *Uncertainty in Risk Assessment* can be read profitably by a broad audience of professionals in the field including researchers and graduate students on courses within risk analysis statistics engineering and the physical sciences *Uncertainty in Risk Assessment* Illustrates the need for seeing beyond probability to represent uncertainties in risk assessment contexts Provides simple explanations supported by straightforward numerical examples of the meaning of different types of probabilities including interval probabilities and the fundamentals of possibility theory and evidence theory Offers guidance on when to use probability and when to use an alternative representation of uncertainty Presents and discusses methods for the representation and characterization of uncertainty in risk assessment Uses examples to clearly illustrate ideas and concepts

**Geotechnical Safety and Risk IV** Limin Zhang, Yu Wang, Gang Wang, Li Dianqing, 2013-11-15 *Geotechnical Safety and Risk IV* contains the contributions presented at the 4th International Symposium on Geotechnical Safety and Risk 4th ISGSR Hong Kong 4-6 December 2013 which was organised under the auspices of the Geotechnical Safety Network GEOSNet TC304 on Engineering Practice of Risk Assessment and Management

and TC205 on Safety and Reliability **The Manager's Guide to Risk Assessment** Douglas M. Henderson FSA, CBCP, 2017-03-21

Risk assessment is required for just about all business plans or decisions. As a responsible manager, you need to consider threats to your organization's resilience. But to determine probability and impact and reduce your risk can be a daunting task. Guided by Douglas M. Henderson's *The Manager's Guide to Risk Assessment: Getting It Right*, you will confidently follow a clearly explained step-by-step process to conduct a risk assessment. As you embark on the risk assessment process, you could not find a better and more uniquely qualified guide than Douglas M. Henderson. His 20 years of experience with major consulting firms includes certification as a professional actuary and business continuity planner. His actuarial knowledge makes him an expert in applying mathematical and statistical methods to help organizations to assess and manage risks. He has applied this real-world knowledge of risk to helping businesses prepare for emergencies and business interruptions of all types. Henderson offers samples and checklists including case studies using a fictional company in which he conducts a complete qualitative risk assessment and then a complete quantitative risk assessment, then arrives at a set of comparable actions. His explanations and sample problems will help you to define risk management terms such as threat, event, and risk control. Identify threats and determine the worst-case situation your organization could face. Collect information on probability for natural and non-natural threats. Understand the difference between qualitative and quantitative risk assessment. Describe probability and impact levels. Identify exposures and examine specific risk controls. Estimate a financial value for implementing a risk control. Determine when outside professional help is needed. As an added bonus, Henderson explores the topic of risk controls with you helping you to evaluate what risk controls will best reduce the probability of disruptive events and reduce their impact should they occur. To insure the best investment of time and money, you will perform a cost-benefit analysis for each possible risk control to make the best choice for your organization.

*Safety and Reliability - Safe Societies in a Changing World* Stein Haugen, Anne Barros, Coen van Gulijk, Trond Kongsvik, Jan Erik Vinnem, 2018-06-15

*Safety and Reliability: Safe Societies in a Changing World* collects the papers presented at the 28th European Safety and Reliability Conference ESREL 2018 in Trondheim, Norway, June 17-21, 2018. The contributions cover a wide range of methodologies and application areas for safety and reliability that contribute to safe societies in a changing world. These methodologies and applications include foundations of risk and reliability assessment and management, mathematical methods in reliability and safety, risk assessment, risk management, system reliability, uncertainty analysis, digitalization and big data, prognostics and system health management, occupational safety, accident and incident modeling, maintenance modeling and applications, simulation for safety and reliability, analysis, dynamic risk and barrier management, organizational factors and safety culture, human factors and human reliability, resilience engineering, structural reliability, natural hazards, security, economic analysis in risk management. *Safety and Reliability: Safe Societies in a Changing World* will be invaluable to academics and professionals working in a wide range of industrial and governmental sectors, offshore oil and

gas nuclear engineering aeronautics and aerospace marine transport and engineering railways road transport automotive engineering civil engineering critical infrastructures electrical and electronic engineering energy production and distribution environmental engineering information technology and telecommunications insurance and finance manufacturing marine transport mechanical engineering security and protection and policy making      Cancer Risk Assessment Ching-Hung Hsu,Todd Stedeford,2010-12-08 With a weight of the evidence approach cancer risk assessment identifies hazards determines dose response relationships and assesses exposure to characterize the true risk This book focuses on the quantitative methods for conducting chemical cancer risk assessments for solvents metals mixtures and nanoparticles It links these to the basic toxicology and biology of cancer along with the impacts on regulatory guidelines and standards By providing insightful perspective Cancer Risk Assessment helps researchers develop a discriminate eye when it comes to interpreting data accurately and separating relevant information from erroneous      The Risk Assessment Guidelines of 1986 United States. Environmental Protection Agency. Office of Health and Environmental Assessment,1987      **Information Technology - New Generations** Shahram Latifi,2017-07-15 This volume presents a collection of peer reviewed scientific articles from the 14th International Conference on Information Technology New Generations held at the University of Nevada at Las Vegas on April 10 12 at Tuscan Suites Hotel in Las Vegas The Book of Chapters addresses critical areas of information technology including web technology communications computing architectures software engineering security and data mining      *Fire Risk Management* Luca Fiorentini,Fabio Dattilo,2023-08-07 FIRE RISK MANAGEMENT Practical methodologies to develop holistic and comprehensive fire safety strategies for buildings and industrial assets In Fire Risk Management Principles and Strategies for Buildings and Industrial Assets a team of distinguished authors delivers an incisive combination of risk management principles and fire safety assessment methods that offers practical strategies and workflows to prevent and mitigate today s complex fire scenarios The book summarizes modern risk based approaches to fire safety discussing fire safety objectives in terms of functional statements performance requirements and detailed protection measures for buildings and industrial assets towards the development of a fire safety case to timely manage risk with a systematic and structured approach throughout the life cycle of the asset The authors introduce the fundamentals of fire safety and design principles before moving on to discuss topics like fire risk assessment methods risk profiles risk mitigation safety management and performance and protective layers and controls Fire Risk Management presents practical methods often borrowed from those successfully used in other domains that can be defined shared and communicated with multiple stakeholders from different backgrounds and with different needs and perspectives Readers will also find A code neutral examination of fire safety principles that is independent of local regulations Discussions of key principle standards including NFPA 550 and ISO 45001 and guidelines on fire risk assessment Practical explorations that connect theory with practice in the real world In depth case studies that walk readers through fire risk management strategies for railway stations



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**Animal Damage Control Program: Appendix P. Risk assessment of wildlife damage control methods used by the USDA Animal Damage Control Program. Appendix Q. USEPA-approved registrations for pesticides used in the APHIS Animal Damage Control Program** Animal Damage Control Program (U.S.),1994      **Health and Safety at Work For Dummies** RRC,2016-05-02 Are you complying with health and safety regulations in the workplace Making mistakes in many areas of health and safety can be both incredibly dangerous and hugely costly So what can you do to avoid hazards and expensive time consuming legal battles That s where Health Safety at Work For Dummies comes in Cutting through the clutter it provides you with the practical must know information you need to ensure your workplace is a suitably safe environment that complies with government health and safety rules and regulations Did you know that in 2014 1 2 million working people suffered from work related illnesses 2 535 mesothelioma deaths occurred due to past asbestos exposure and 133 workers were killed on the job The list goes on and the statistics are staggering Health Safety at Work For Dummies shows you how to keep your employees safe from becoming another statistic in this frightening data Arming you with critical information needed to adhere to health and safety regulations it offers expert guidance on managing and implementing health and safety in your business controlling workplace risks going the extra mile in following orders and much more Offers an easy to follow overview for getting started with health and safety Provides tips and advice for planning your health and safety management Includes guidance on monitoring and reviewing your health and safety systems Clearly demonstrates how to organize and motivate your workforce to comply with rules and regulations You can t afford to run a business that doesn t provide a safe work environment Be smart safe and proactive with the help of this essential guide

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