

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Risk management – Risk assessment techniques

Management du risque – Techniques d'appréciation du risque



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2019 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Risk management – Risk assessment techniques

Management du risque – Techniques d'appréciation du risque

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 03.100.01

ISBN 978-2-8322-6989-3

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	9
4 Core concepts	10
4.1 Uncertainty	10
4.2 Risk	11
5 Uses of risk assessment techniques	11
6 Implementing risk assessment.....	12
6.1 Plan the assessment.....	12
6.1.1 Define purpose and scope of the assessment	12
6.1.2 Understand the context.....	13
6.1.3 Engage with stakeholders.....	13
6.1.4 Define objectives	13
6.1.5 Consider human, organizational and social factors	13
6.1.6 Review criteria for decisions	14
6.2 Manage information and develop models	16
6.2.1 General	16
6.2.2 Collecting information	16
6.2.3 Analysing data.....	16
6.2.4 Developing and applying models	17
6.3 Apply risk assessment techniques.....	18
6.3.1 Overview	18
6.3.2 Identifying risk	19
6.3.3 Determining sources, causes and drivers of risk	19
6.3.4 Investigating the effectiveness of existing controls.....	20
6.3.5 Understanding consequences, and likelihood	20
6.3.6 Analysing interactions and dependencies	22
6.3.7 Understanding measures of risk.....	22
6.4 Review the analysis	25
6.4.1 Verifying and validating results	25
6.4.2 Uncertainty and sensitivity analysis	25
6.4.3 Monitoring and review.....	26
6.5 Apply results to support decisions.....	26
6.5.1 Overview	26
6.5.2 Decisions about the significance of risk	27
6.5.3 Decisions that involve selecting between options.....	27
6.6 Record and report risk assessment process and outcomes	28
7 Selecting risk assessment techniques.....	28
7.1 General.....	28
7.2 Selecting techniques.....	29
Annex A (informative) Categorization of techniques	31
A.1 Introduction to categorization of techniques	31
A.2 Application of categorization of techniques	31
A.3 Use of techniques during the ISO 31000 process.....	37

Annex B (informative) Description of techniques	40
B.1 Techniques for eliciting views from stakeholders and experts.....	40
B.1.1 General	40
B.1.2 Brainstorming	40
B.1.3 Delphi technique.....	42
B.1.4 Nominal group technique	43
B.1.5 Structured or semi-structured interviews	44
B.1.6 Surveys	45
B.2 Techniques for identifying risk.....	46
B.2.1 General	46
B.2.2 Checklists, classifications and taxonomies.....	47
B.2.3 Failure modes and effects analysis (FMEA) and failure modes, effects and criticality analysis (FMECA)	49
B.2.4 Hazard and operability (HAZOP) studies.....	50
B.2.5 Scenario analysis	52
B.2.6 Structured what if technique (SWIFT)	54
B.3 Techniques for determining sources, causes and drivers of risk	55
B.3.1 General	55
B.3.2 Cindynic approach	56
B.3.3 Ishikawa analysis (fishbone) method	58
B.4 Techniques for analysing controls	60
B.4.1 General	60
B.4.2 Bow tie analysis.....	60
B.4.3 Hazard analysis and critical control points (HACCP).....	62
B.4.4 Layers of protection analysis (LOPA).....	64
B.5 Techniques for understanding consequences and likelihood	66
B.5.1 General	66
B.5.2 Bayesian analysis.....	66
B.5.3 Bayesian networks and influence diagrams.....	68
B.5.4 Business impact analysis (BIA).....	70
B.5.5 Cause-consequence analysis (CCA).....	72
B.5.6 Event tree analysis (ETA)	74
B.5.7 Fault tree analysis (FTA)	76
B.5.8 Human reliability analysis (HRA).....	78
B.5.9 Markov analysis.....	79
B.5.10 Monte Carlo simulation	81
B.5.11 Privacy impact analysis (PIA) / data protection impact analysis (DPIA).....	83
B.6 Techniques for analysing dependencies and interactions	85
B.6.1 Causal mapping.....	85
B.6.2 Cross impact analysis.....	87
B.7 Techniques that provide a measure of risk	89
B.7.1 Toxicological risk assessment.....	89
B.7.2 Value at risk (VaR)	91
B.7.3 Conditional value at risk (CVaR) or expected shortfall (ES)	93
B.8 Techniques for evaluating the significance of risk	94
B.8.1 General	94
B.8.2 As low as reasonably practicable (ALARP) and so far as is reasonably practicable (SFAIRP)	94

B.8.3	Frequency-number (F-N) diagrams	96
B.8.4	Pareto charts	98
B.8.5	Reliability centred maintenance (RCM)	100
B.8.6	Risk indices	102
B.9	Techniques for selecting between options	103
B.9.1	General	103
B.9.2	Cost/benefit analysis (CBA)	104
B.9.3	Decision tree analysis	106
B.9.4	Game theory	107
B.9.5	Multi-criteria analysis (MCA)	109
B.10	Techniques for recording and reporting	111
B.10.1	General	111
B.10.2	Risk registers	112
B.10.3	Consequence/likelihood matrix (risk matrix or heat map)	113
B.10.4	S-curves	117
	Bibliography	119
	Figure A.1 – Application of techniques in the ISO 31000 risk management process [3]	37
	Figure B.1 – Example Ishikawa (fishbone) diagram	59
	Figure B.2 – Example of Bowtie	61
	Figure B.3 – A Bayesian network showing a simplified version of a real ecological problem: modelling native fish populations in Victoria, Australia	69
	Figure B.4 – Example of cause-consequence diagram	73
	Figure B.5 – Example of event tree analysis	75
	Figure B.6 – Example of fault tree	77
	Figure B.7 – Example of Markov diagram	80
	Figure B.8 – Example of dose response curve	89
	Figure B.9 – Distribution of value	91
	Figure B.10 – Detail of loss region VaR values	91
	Figure B.11 – VaR and CVaR for possible loss portfolio	93
	Figure B.12 – ALARP diagram	95
	Figure B.13 – Sample F-N diagram	97
	Figure B.14 – Example of a Pareto chart	98
	Figure B.15 – Part example of table defining consequence scales	114
	Figure B.16 – Part example of a likelihood scale	114
	Figure B.17 – Example of consequence/likelihood matrix	115
	Figure B.18 – Probability distribution function and cumulative distribution function	117
	Table A.1 – Characteristics of techniques	31
	Table A.2 – Techniques and indicative characteristics	32
	Table A.3 – Applicability of techniques to the ISO 31000 process	38
	Table B.1 – Examples of basic guidewords and their generic meanings	51

Table B.2 – Table of deficits for each stakeholder	57
Table B.3 – Table of dissonances between stakeholders	57
Table B.4 – Example of Markov matrix	80
Table B.5 – Examples of systems to which Markov analysis can be applied	81
Table B.6 – An example of RCM task selection	101
Table B.7 – Example of a game matrix	108

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RISK MANAGEMENT –
RISK ASSESSMENT TECHNIQUES**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 31010 has been prepared by IEC technical committee 56: Dependability, in co-operation with ISO technical committee 262: Risk management.

It is published as a double logo standard.

This second edition cancels and replaces the first edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- more detail is given on the process of planning, implementing, verifying and validating the use of the techniques;
- the number and range of application of the techniques has been increased;
- the concepts covered in ISO 31000 are no longer repeated in this standard.

The text of this International Standard is based on the following documents of IEC:

FDIS	Report on voting
56/1837/FDIS	56/1845/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table. In ISO, the standard has been approved by 44 P members out of 46 having cast a vote.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document provides guidance on the selection and application of various techniques that can be used to help improve the way uncertainty is taken into account and to help understand risk.

The techniques are used:

- where further understanding is required about what risk exists or about a particular risk;
- within a decision where a range of options each involving risk need to be compared or optimized;
- within a risk management process leading to actions to treat risk.

The techniques are used within the risk assessment steps of identifying, analysing and evaluating risk as described in ISO 31000, and more generally whenever there is a need to understand uncertainty and its effects.

The techniques described in this document can be used in a wide range of settings, however the majority originated in the technical domain. Some techniques are similar in concept but have different names and methodologies that reflect the history of their development in different sectors. Techniques have evolved over time and continue to evolve, and many can be used in a broad range of situations outside their original application. Techniques can be adapted, combined and applied in new ways or extended to satisfy current and future needs.

This document is an introduction to selected techniques and compares their possible applications, benefits and limitations. It also provides references to sources of more detailed information.

The potential audience for this document is:

- anyone involved in assessing or managing risk;
- people who are involved in developing guidance that sets out how risk is to be assessed in specific contexts;
- people who need to make decisions where there is uncertainty including:
 - those who commission or evaluate risk assessments,
 - those who need to understand the outcomes of assessments, and
 - those who have to choose assessment techniques to meet particular needs.

Organizations that are required to conduct risk assessments for compliance or conformance purposes would benefit from using appropriate formal and standardized risk assessment techniques.

RISK MANAGEMENT – RISK ASSESSMENT TECHNIQUES

1 Scope

This International Standard provides guidance on the selection and application of techniques for assessing risk in a wide range of situations. The techniques are used to assist in making decisions where there is uncertainty, to provide information about particular risks and as part of a process for managing risk. The document provides summaries of a range of techniques, with references to other documents where the techniques are described in more detail.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO Guide 73:2009, *Risk management – Vocabulary*

ISO 31000:2018, *Risk management – Guidelines*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 31000:2018, ISO Guide 73:2009 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

likelihood

chance of something happening

Note 1 to entry: In risk management terminology, the word "likelihood" is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically (such as a probability or a frequency over a given time period).

Note 2 to entry: The English term "likelihood" does not have a direct equivalent in some languages; instead, the equivalent of the term "probability" is often used. However, in English, "probability" is often narrowly interpreted as a mathematical term. Therefore, in risk management terminology, "likelihood" is used with the intent that it should have the same broad interpretation as the term "probability" has in many languages other than English.

[SOURCE: ISO 31000:2018, 3.7]

3.2

opportunity

combination of circumstances expected to be favourable to objectives

Note 1 to entry: An opportunity is a positive situation in which gain is likely and over which one has a fair level of control.