inRisk | software-guide to register, map, analyse and prevent accidents

Content

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

inRisk | software-guide to register, map, analyse and prevent accidents

Overview: Need for better Incident Investigation

Accidents are threats of life and environment, whether they really happened, nearly happened or might happen. Their threats result from their specific *risk* and this is the result of its *probability* and *severity*. There is e.g. the *risk* of a "incised wound", with a comparable high *probability* and a low *severity*. On the other hand there is the *risk* of a "reactor disaster" with a quite low *probability* but an extreme *severity*. Both *risks* arise from hazardous influences - given by laws of nature and overseen or accepted in enterprises. And both *risks* will persist as long as we cut with a knife and operate nuclear power plants and do not eliminate their hazardous influences or reduce at least their impacts on *probability* and *severity*.

Safety is promoted by governments, their legislations and regulations. Federal Institutions control the compliance of rules and monitor developments in the field of safety. Insurances bear the financial consequences of incidents. Most companies set *safety* as their primary objective for products and employees. A large number of official and internal investigators analyse incidents. And man himself at least has the intrinsic motivation to be safe. No other topic has so wide-ranging advocates.

The number of work-/ and industrial-incidents slightly decreased over the last decade. But the rate of unsolved cases with unknown and unclear causes remained constant: More than 20% of industrial-incidents have *unknown causes*[1)] and more than 80% of work-accidents have *unclear causes*[2)]. But an accident, with unclear causes, cannot be prevented- its *risk* persists.

The consequences can be calculated from a financial perspective, beyond the impacts on human life and environment:

- each reportable industrial-accident costs 3 Mio €; damages with unsolved causes sum up to 26 Mio €/a[1)]
- 80 million €/a paid merely for early retirements as consequences of work-accidents with unclear causes[3)]

And these are only the rates for the published incidents - with a hardly assessable dark figure of all incidents. The potential of prevention is unknown but not negligible.

This convinced a Chemical Company in Germany to improve the detection-rate of its threats of life, environment and budget. They set up an incentive plan encouraging employees to indicate *all* real-/ and near-incidents and thus extended their rate of recorded real-/ and near-incidents by the factor of ten. Additionally we, activepartner, were mandated to improve the used investigation methods by transferring and adapting methods of process-analyses to the topic of incident-analysis.

Any incident is the unique result of an interaction of objects, laws of nature and people in a unique course of events. We saw that investigators often were specialists for objects and for laws of nature but not for their interaction with people. And not for incidents. They act like detectives in an area of complex circumstances with people who cover responsibilities. Their tools were provided from quality management, established for the investigation of defects in serial products but not well suited for the investigation of unique incidents. There were no standard tools, no rules to select tools, no rules to arrange or link tools to a comprehensive method. Consequently there was no guidance for investigators on their path from recording the incident to auditing the implemented preventive measures and the results showed weaknesses in precision, validity and reliability.

What did we do? We believe that each incident is unique but all incidents have commonalities. This creates opportunities.

- **Model the incident:** rebuild the course of events, assign injuries/damages, identify influences and their causes.
- **Prepare the decisions:** rank preventive measures according to their cost-benefit ratio.
- **Guide the investigator:** offer an unambiguous investigation-path and use interview-techniques to lead the investigator.

inRisk was developed along these guidelines. It will be described on the next pages.

1) ZEMA des Umweltbundesamtes/ The Central Reporting and Evaluation Office for Major Accidents at the Federal Environment Agency: ZEMA annual reports (2000-2009)
2) Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) / Federal Institute for Occupational Safety and Health: Sicherheit und Gesundheit bei der Arbeit (2000-2009)
3) Deutsche gesetzliche Unfallversicherung DGUV/ German social insurance: DGUV Statistics (2000 -2010)

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

inRisk | software-guide to register, map, analyse and prevent accidents

Situation: Industrial– and Work-Incidents

inRisk is a software-guide that aims to prevent work-/ and industrial-accidents. It supports to increase safety in working environments and thus supports a basic human need: "Every person has the right to live and to be physically unharmed" (German Constitutional Law). Many countries enforce the investigation of work-/ and industrial-accidents.

inRisk aims at the gap between a slightly decreasing number of accidents in the last decade and its constant portion of unsolved cases. Today investigators have to rely on their individual selection of tools from the quality-management-box, supplemented by their expertise and common sense. There are no standards, neither recommendations. Consequently different investigators come to different results. And more than 20% of the cases remain unsolved and thus without prevention.

Facts & Figures

Industrial incidents

- 2 reportable industrial-incidents per month in Germany
- 23% of the causes of are unknown
- 25% of the industrial-incidents happen due to unclear human-error-causes
- Ø 3 million € costs for each reportable industrial-incident
- Ø every 4th employee in chemical industry is involved in an not-reportable incident/ a
- Nearly uncountable number of investigators of incidents

Work Accidents

- 3100 reportable work-accidents every day in Germany
- 2700 reportable work-accidents / day have unclear causes
- 77 work-accidents/ day result in an early retirement
- 62 reportable work-accidents/ day have unknown causes
- 80 million €/a paid out for accidents with unclear causes
- 2900 investigators solely at legal insurance in Germany

Focus & Future

"Within the last 15 years we have seen that … there has been a steady increase of the proportion of human failure as the cause for incidents. The area of technical reliability has so far been optimized that the **fact of human failure as the cause of incidents has become more importance within the field of incident prevention**." [1)]

"**Human failure is often named as the cause of accidents, without first considering the producer responsibility to produce products with a safe and health-conform design**." [2)]

Representatives of the German statutory accident insurance (DGUV), the Commission for the plant safety (KAS) and the Federal Department for the Environment (UBA) **complain that there are neither standard methods nor standard tools for the analysis of incidents.**

Federal Institute for Occupational Safety and Health (BAuA) together with the TÜV started a research project in 2012: **„Investigation of root causes of accidents, industrial incidents and near-incidents for prevention." (F 2287)** [3)]

1) Störfallkommission beim Bundesministerium Umwelt, Naturschutz und Reaktorsicherheit: Statusbericht des Arbeitskreises Human Factors SFK-GS-46 (2005)
2) Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) / Federal Institute for Occupational Safety and Health: Sicherheit und Gesundheit bei der Arbeit 2009
3) Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) / Federal Institute for Occupational Safety and Health: Ganzheitliche Ereignisanalyse effektiv und effizient durchführen

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

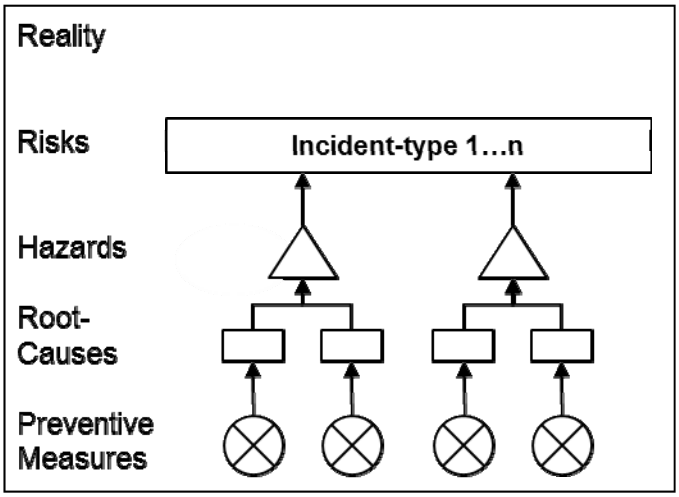
inRisk | software-guide to register, map, analyse and prevent accidents

Method: Variants of Risk-Management

Risk-management means to identify hazards with impact on the risk of certain incidents, like environmental-, industrial-, work- and traffic-accidents, as well as system-reliability and financial-incidents. The objective is to reduce the risk of the incident, by eliminating root-causes of the hazards to reduce its probability or to cushion the impacts of an incident to reduce its severity.

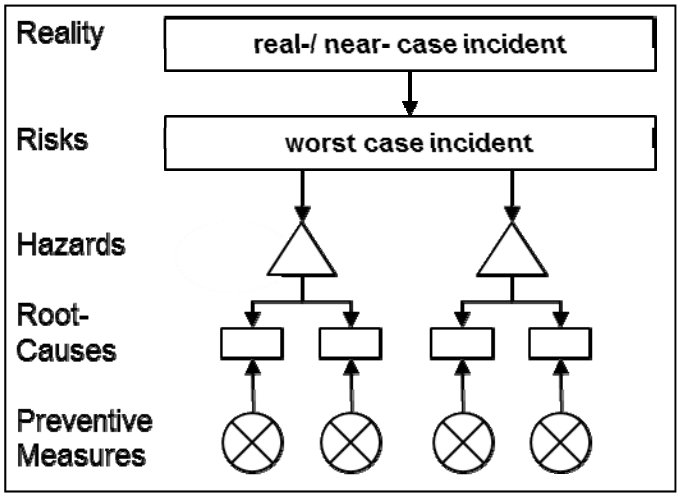
There is an proactive and reactive way to achieve this. The proactive way tries to predict certain, system-relevant incidents on the basis of a certain set of supposed hazards. The a priori elimination of root-causes of hazards and the increase of the reliability of components of the system is the primary strategy to reduce risks. There are a some elaborated statistical- and logically based methods also integrating software tools to support this proactive analysis. Their disadvantage is, that they can not reactively analyse a certain real- or near-incident, break it down into its root-causes to develop preventive measures.

E.g. Fault-Tree: proactive analysis



- known hazards lead to certain critical/ focused incidents
- known root-causes lead to hazards
- preventive measures eliminate root-causes

inRisk: reactive analysis



- real-/ near incident is the template for its worst case
- worst case is analysed for possible hazards
- hazards are broken down to root-causes
- preventive measures eliminate root-causes

Comparison of tools & supplier

- **Methods for proactive analysis:**
  - Probabilistic Safety Analysis
  - Reliability- & Lifecycle Analysis
  - Event-Tree/ Fault-Tree
  - FMEA/ FMECA
  - Markov-Chains
  - Monte-Carlo-Analysis
- The challenge is to find the appropriate tool for the case
- A lot of suppliers offer SW-tools for these procedures

- **Methods for reactive analysis:**
  - Process-Mapping
  - Cause & Effect Analysis/ Ishikawa-Diagram
  - Reverse Fault-Tree
  - Boolean algebra
  - Barrier- & Influence-Thinking
  - Failure-Modeling
- The challenge is to combine the tools in one model (inRisk)
- There is no competitor to offer an integrated SW-tool

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

inRisk | software-guide to register, map, analyse and prevent accidents

Method: Investigation Pathways

inRisk is a software to analyse any incidents like industrial-/ environmental-/ and work-accidents. It arrays all necessary tools and links them in a chrono-logical sequence which determines the pathway of the investigation, from registration of the incident to the audit of its preventive measures. The adaption of established tools, their integration in a comprehensive method together with some complete new ideas will improve the quality, economy and usability of the investigation.
inRisk allows to investigate any real-/ and near-accident. The integrated mapping of the course of events, the identification of influences and their root-cause-analysis allows to separately calculate the effectivity and efficiency of every planned measure. Four pathways with different depths of analysis allow to adapt the investigation effort to the degree of risk of the actual case. An adaptive interview-framework, with continuous checks guides the user to gather detailed, gapless and consistent information and thus helps to reduce the cognitive and emotional load during the investigation.

Process of investigation

- **DEFINE:** Specify actual injuries and damages, give a draft analysis of the incident, specify the worst case and calculate its *risk*.
- **MEASURE:** Specify the course of events as a sequence of significant scenes. Assign the specified injuries/ damages to the scenes, discover their harmful attributes and determine their hazard-status.
- **3. ANALYSE:** Search for negative influences which a) disrupt the course of events or b) affect safety devices. Break these influences down to their root-causes and calculate their impact on the *severity* and *probability*. Rank root-causes by their impact.
- **4. IMPROVE:** Define preventive measures to circumvent, change or eliminate the root-causes. Rank them according to their effectivity and efficiency and decide which measures should be implemented.
- **5. CONTROL:** Monitor progress of and calculate the remaining *risk* after implementation as well as the utilized potential and efficiency of risk-reduction. Audit the overall success and distribute the report.

Features & Benefits

- Supports investigation of any kind of incident
- Depth of analysis depends on the degree of *risk* and thus supports economic needs. It ranges from a snapshot overview to a full analysis including recommendations of preventive measures on the basis of their cost-benefit-ratio
- Separate determination of influences on the *probability* and the *severity* of the incident allow to distinguish between preventive and corrective measures
- Calculates the efficiency of planned measures, the potential they utilize and shows sources of lost potential
- Guides the investigator stepwise within an adaptive interview framework, with questions asked in complete sentences, build on the content of the previous given answer
- Seamless stream of requested and given information, summarised in checks allow to immediately identify gaps, contradictions, tautologies and shows the need for details
- Framework can serve as „Team Member“ or „Hidden Interviewer“ which can intuitively be understood and thus compensates low levels of experience
- Controls the improvement project and generates reports

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

inRisk | software-guide to register, map, analyse and prevent accidents

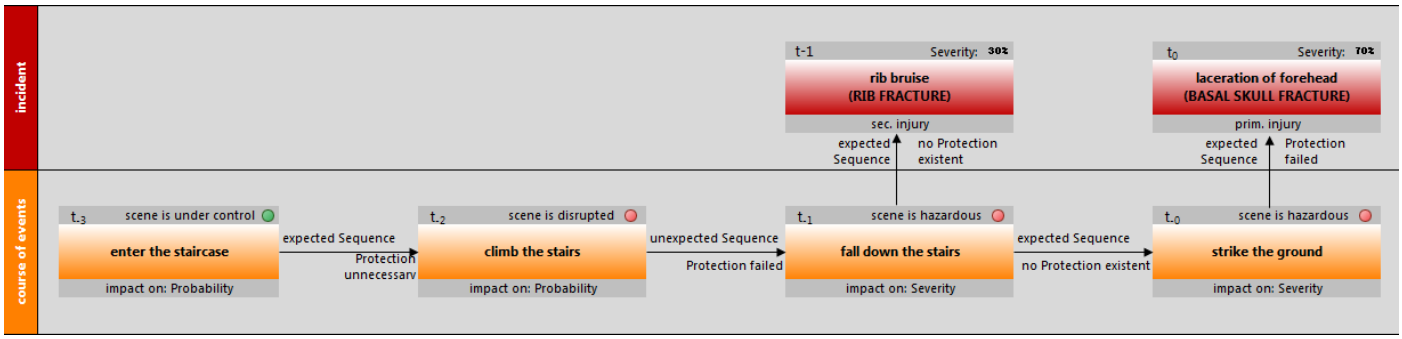
Method: Mapping of Incident

inRisk is based on the idea, that an incident can only be explained, if its course of events is transparent. To map the course of events a generic **I**nput-**P**rocess-**O**utput-Structure is used. It serves as mockup to model the flow of all types of incidents.

inRisk is based on the idea, that immediately prior to the accident the Person/ technical-system is always part of a controlled routine process. This routine is then actively disrupted by a trigger of the accident or passively disrupted by the omission of a protection. As a consequence the process gets out of control and leads to the injury/ damage. This means: the causes of the injury/ damage are embedded in the process, i.e. in the uniqueness of this course of events.

inRisk specifies the course of events as a sequence of significant scenes. The scenes are then analysed to identify trigger of the incident with impact on the *probability* and aggravating influences with impact on the *severity* of the incident.

Incident as a sequence of significant scenes, related to injuries and damages



- Every course of events is structured into at least 3 significant scenes, which show the changes of the process, first being *under control*, then *disrupted* and leading to at least one *hazardous* scene which leads to at least one injury/ damage. ***new***
- The loss of control in this sequence is determined by influences: trigger affect the sequence and thus have an impact on the *probability* of the incident. Failed protection prior to injuries/ damages affect the *severity* of the incident. ***new***
- Thus in the further analysis it is necessary to identify these influences and to break them down to their root-causes.
- This breakdown is done logically and numerically in a reverse fault-tree allowing to quantify the impacts of causes. ***new***
- These root-causes are the anchor positions for preventive measures, aimed to eliminate or circumvent the causes.

Features & Benefits

- Generic Input-Process-Output structure as basic mockup
- Adaptions of the mockup allow to analyse any type of incident, real-, near-, accidents, damages and defects
- Intuitive description of the course of events as a sequence of significant scenes with clear rules to keep track
- Intuitive description of scenes allows to distinguish between impacts on the sequence of scenes and impacts on the protection of scenes or protection of injures/ damages
- Impacts on a scene determine its hazard-status and thus prepare the next step: the specific search for trigger and aggravator with impact on the *probability* on the *severity*
- To eliminate influences on the *probability* means to proactively prevent the incident in the future, e.g. using a handrail in a staircase to prevent to fall down
- To eliminate influences on the *severity* means to reactively absorb the impact of an ongoing incident, like using a helmet in a staircase

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

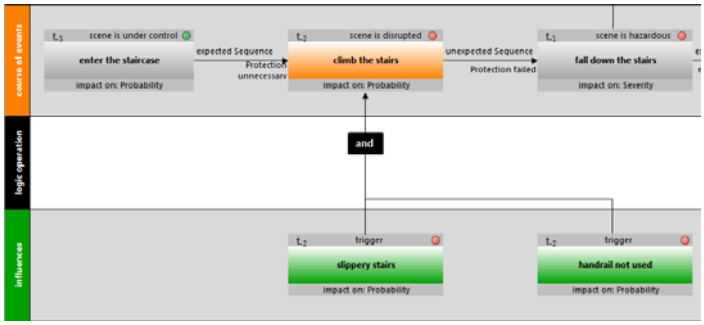
inRisk | software-guide to register, map, analyse and prevent accidents

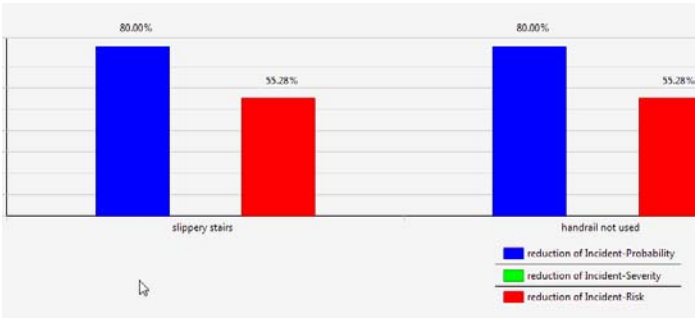
Method: Analyse of Incident

inRisk aims to reduce the *risk* of any real- or near-incident by identifying its trigger and additional aggravator, deriving their root-causes and eliminating or circumventing them by preventive measures. The *accuracy*, *validity* and *precision* of the identified root-causes naturally depend on the quality of the underlying analysis. There are tools on the market which can map a process, others identify causes or calculate the probability of an incident on the basis of their underlying causes. But no tool does all of this in an integrated method. And no tool can break down a given *risk* to its causes and separately calculate their impact on the *probability* and *severity* to separately develop preventive measures for causes with the strongest impacts.

inRisk delivers an integrated mockup by first modeling its course of events as a sequence of significant scenes, then identifies the influences on the scenes, breaks down influences to their root causes and calculates their specific impact on the risk. This is the starting point to develop *accurate*, *valid* and *precise* preventive measures and the ranking of their cost/ benefit ratio.

Preparation of decisions





- Changes of a process, from being: *under control* to: *out of control* are due to disrupting trigger in a specific scene
- Trigger of a scene have impacts on the *probability* of a *risk*
- Aggravating influences affect the *severity* of a *risk*
- The *accuracy* of an analysis depends on the separation of these influences because it allows to taylor specific measures. Reducing the *probability* of a *risk* means to reduce ist occurrence. Reducing the *severity* means to absorb the effects of an ongoing incident. ***new***
- The *validity* of the analysis depends on the logical breakdown of these influences to root-causes
- The *precision* of the analysis depends on the numerical breakdown of impact strengths along the specified logical operations. This is realized in a reverse fault-tree. ***new***
- Root-causes are anchor points for the development of preventive measures. If the impact of a root-cause is known and the costs of a measure can be estimated, then the measures can be ranked according to their effectivity and efficiency. This is the best a rational basis for decisions. ***new***

Features & Benefits

- Improved *accuracy* of analysis by dividing a *risk* into its constituents: *probability* and *severity*
- Improved *validity* of analysis by logically breaking down the direct influences on a scene to underlying root-causes
- Improved *precision* of analysis by breaking down the *risk* to quantify impact strengths of underlying root-causes
- Defined anchor points for the development of measures
- Measures can be tailored to reduce the occurrence of a *risk* or absorb the effects of an ongoing incident
- Ranking of planned measures according to their effectivity and efficiency supports rational cost/ benefit decisions
- Quantitative statements about the potential to reduce *risk,* their actual usage and the sources of lost potentials
- Depth of analysis varies according to the degree of risk
- The underlying generic mockup as well as actual derived reports are easy to understand and easy to justify

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

inRisk | software-guide to register, map, analyse and prevent accidents

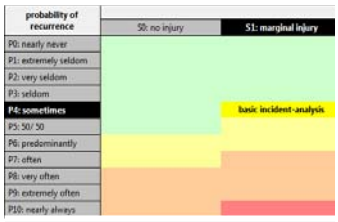
Usability: Adaption to Requirements

The investigator of an incident is typically confronted with a unknown dynamic of complex events and with a hidden structure of influences and causes. To create transparency the investigator has to systematically ask for information, evaluate answers and specify details, link information, check plausibility and calculate impacts. This might lead to an information overload. Some investigators rely on tools like FMEA or Cause&Effect-Analysis and add their professional experience and common sense. In consequence the results will differ from investigator to investigator. If additionally witnesses are involved, who might want to cover up responsibilities, the poorness of detail might camouflage contradictions and mislead the investigator.

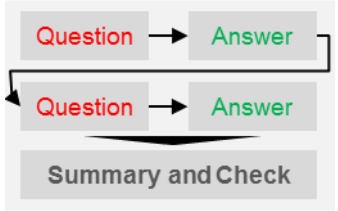
inRisk aims to guide a user through the investigation, from the registration to the audit of success. The adaption takes place on three different levels: on basis of a *generic mockup*, various *depths of analysis*, within an *interactive interview framework*.

Adaption to the topic, to the case and to the user *new*

- The *generic mockup* is based on an Input-Process-Output-Model, combined with a Cause & Effect-Analysis plus reversed fault-tree supplemented by project management and auditing.
- The investigation path with all branches and terminations is completely determined by the mockup, by logical reasoning and numerical rankings. It is unambiguous defined over the whole path of investigation, from the registration of the incident to the audit of success.



- Via description of the worst case of the given incident, the estimation of its *probability* and *severity* of a occurrence, the *risk* of this incident is calculated.
- Depending on the degree of *risk* the appropriate analysis is recommended, varying from: 1) **no analysis**, 2) **basic incident analysis**, 3) **extended** to 4) **full incident analysis**.
- The user is then guided on the recommended path with the appropriate *depth of analysis*



- In order to receive detailed information the user is guided within an *interactive interview-framework*. Questions are asked in complete sentences with blank spaces for the answers.
- The given answer is then picked up and becomes part of the next question. Then after relating information, it is summarized and has at least to be checked before continuing.
- Thus a seamless investigation is achieved where gaps and contradictions become apparent.

Features & Benefits

- Adaption to topic: Generic mockup of an incident together with a generic problem-solving-procedure allows to model the investigation of all kinds of incidents leading to a clear and unambiguous guidance of the investigator. This reduces the amount of false and incomplete analyses.
- Adaption to case: Depending on the degree of risk, one of four paths through the model with different depths of analysis is recommended. This allows to adapt time and effort to the economic requirements of the case.
- Adaption to user: Guided interview framework where information is requested in complete questions and the given answer builds the content of the next question. Summaries with checks complete each step. This modeling of a natural investigation situation with interlinked contents leads to a seamless flow of information. Missing or sketchy information, contradictions and tautologies will become transparent. These principles will reduce the amount of necessary training and is suitable to guide investigators with different educational backgrounds and expertise.

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de

inRisk | software-guide to register, map, analyse and prevent accidents

Chance is a word void of sense; nothing can exist without a cause.

Voltaire (1694 – 1778)

copyright: Dr. Reiner Hutwelker | **tel:** +49 (08193) 700 290 | **eMail:** kontakt@softlogik.de