Systematic root cause analysis with SOL [1]

(SOL – Safety through Organizational Learning)

Rainer Miller, MTO Safety GmbH, 2021

1. Learning from Operational Experience and Root Cause Analysis

Learning from operational experience is one of the most important methods for improving safety and reliability of organizations. This learning is often a learning from undesired activities, disturbances or incidents ("events"). **A prerequisite for learning is a systematic analysis of the causes in order to be able to implement improvement measures in a goal-oriented manner (root cause analysis).**

Root cause analysis (RCA) is about **reconstructing an event and identifying those factors that contributed to its occurrence.** The essential goal of RCA is organizational learning, i.e., the ability of an organization to continuously improve safety and reliability through targeted measures.

The method "SOL - Safety through Organizational Learning" allows the causes of events to be systematically analyzed and learning from experience is effectively supported.

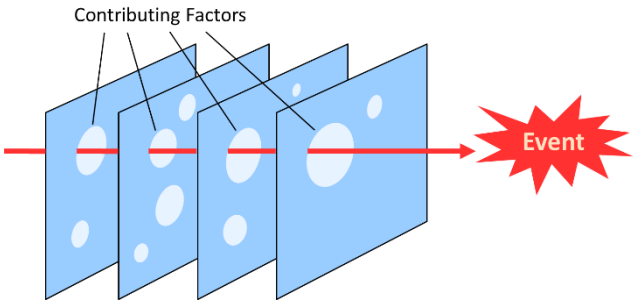
2. Human and Organizational Factors

In 1992, the Institute of Psychology at the Berlin University of Technology began to develop and test the methodology "SOL - Safety through Organizational Learning" for the systematic analysis of causes. [Wilpert et al., 1997]. SOL was developed with the aim of effectively supporting learning from experience and facilitating the identification of Human and Organizational Factors (HOF) as causes of events. The further development of SOL, the programming of the SOL software and the commercial distribution have been the responsibility of MTO Safety GmbH since 2011.

In order to enable a more detailed view for the analysis of events, a **system model** with five areas was developed: Technology, Individual, Group, Organization and Organizational Environment. This model makes it possible to examine in detail all the facts and interactions relevant to safety [Wilpert, 2000].

[1] SOL ® is a trademark of MTO Safety GmbH registered at the European Union Intellectual Property Office (EUIPO).

3. Emergence of Accidents and Incidents



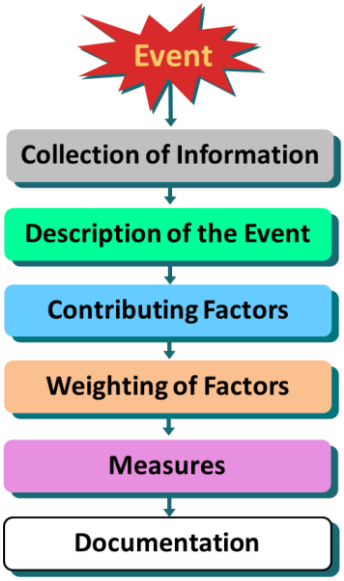
In safety-critical systems, safety is created by setting up staggered safety barriers. In the figure, this is illustrated in accordance with J. Reason's "Swiss Cheese Model".

Barriers ("cheese slices") are all kinds of technical, human and organizational safety measures. However, barriers are never 100% effective, but have certain weak points, i.e. they are permeable at certain points. Unwanted events then only occur due to the unforeseen and coincidental interaction of weak points in the barriers, due to corresponding holes in the cheese slices.

Only the simultaneous occurrence of several weak points or "**contributing factors**" can cause an undesirable event (accident, incident, etc.). In this understanding, events are described as a chain of separate events and as the result of the complex interaction of factors that can originate from the five areas of the system model (technology, individual, group, organization and organizational environment).

Weak points that are far away from the event are often difficult to identify, but relevant for learning from events. An example: In a chemical plant, the actuation of a valve causes a sudden failure of this valve and an unintentional release of substances. This failure of a technical component is a cause of the release. Another contributing organizational factor would be, for example, the fact that valves of this design have failed more frequently - without this having led to any measures (e.g. replacement, improved maintenance) in the plant. The use of SOL for a root cause analysis also enables the recording of such underlying causes from the area of Human and Organizational Factors (HOF).

4. Process of an Root Cause Analysis with SOL®



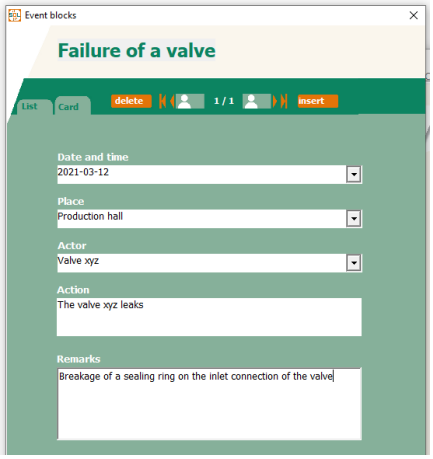
The process of an event analysis with SOL is divided into six steps: collection of information, description of the event using event building blocks, identification of contributing factors, weighting of factors, determination of measures and documentation of the analysis. The SOL software and the instructions available for the analysis support all steps of the analysis: in the preparation of the information from the information collection, in the preparation of the event description, in the identification and weighting of contributing factors and in the documentation of the event.

Collection of Information

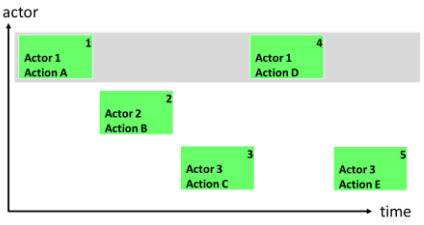
In the first step of an RCA with SOL, the "collection of information", as much information as possible is collected on the course of events, The actions of persons, their intentions and the basis of their actions, and about other relevant conditions.

Event Description with Event Building Blocks

The collected information is then systematically recorded and sorted. For this purpose, the course of the event is broken down into individual "**event building blocks**". Event building blocks are **individual actions by individual actors**. Only objectively recordable data is included in the event building blocks - questions about the cause of an action are not asked at this point. The event building blocks are then arranged chronologically and according to actors. The result is a clear graphical representation of the event modules along the time axis, the time-actor diagram. There, for example, all the actions of an actor are lined up and can thus be easily identified.



In the SOL software[2], the following information can be entered for the event modules: time and place of the action, name of the actor, description of the action, and free fields for additional information (field "Remarks"). This information is all made visible in the time-actor diagram. Furthermore, notes and source information can be stored for the event module, which do not appear in the documentation.



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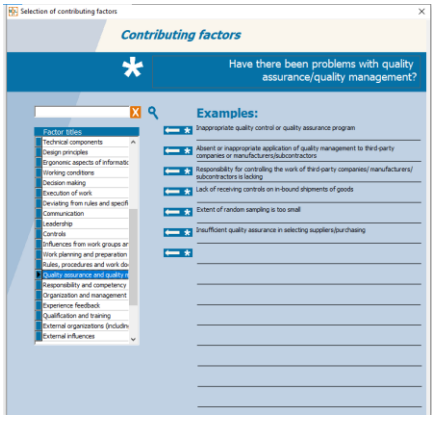
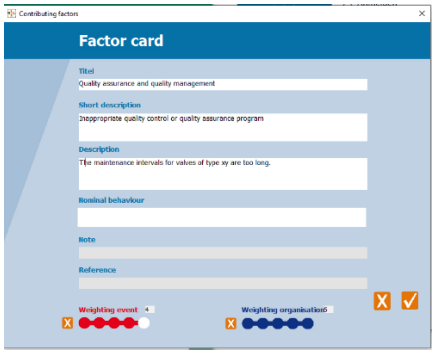
Identification of Contributing Factors

In the "identification of contributing factors", the causes of the event are determined. For this purpose, each event building block is individually questioned as to what was not optimal at this step, or what needs to be improved at this point. These identified weaknesses are then assigned to one of **20 categories**, the "contributing factors" of the SOL methodology. The identification of the contributing **factors is supported by an identification aid with numerous examples** that explain the contributing factor in more detail. This makes it easy for non-human factors experts to carry out an RCA.

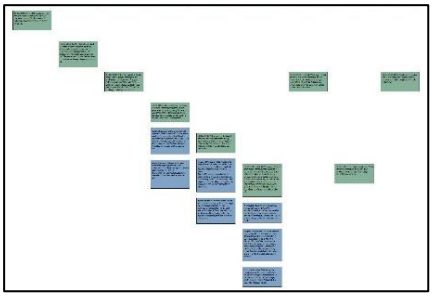


The contributing factors identified are each documented on a factor card. Here, a detailed description is given for each of the contributing factors. Furthermore, the contributing factors can be weighted on two dimensions: with regard to their importance for the analyzed event and with regard to their importance for the learning success of the organization.



[2] The software can be obtained from MTO Safety GmbH (www.sol-rca.com).

The identified contributing factors are assigned to the event building blocks. The resulting "time-actor diagram" provides a simple overview of the event and the contributing factors and facilitates the documentation of the analysis.



5. Conditions of an Analysis

To minimize judgement bias and typical human errors of reasoning [Fahlbruch, 2000], a SOL analysis should always be carried out in a team. A suitable composition of the team can ensure that different expertise (technical knowledge, human factors expertise) flows into the analysis.

To ensure an effective and comprehensive analysis, training in the SOL procedure is necessary. MTO Safety has developed a "Training Programme for Root Cause Analysis" for users, which consists of a basic seminar "Understanding Human Factors" and an advanced seminar "Causal Analysis with SOL".

The analysis of events within an organization is threatened by multiple resistances and barriers to learning [Miller, Wilpert & Fahlbruch, 1999]. In order to ensure organizational learning, it is necessary that all stakeholders trust that the results of the analysis cannot lead to negative consequences. It is therefore important that a clear and credible commitment is made by all those involved and responsible that the analysis will not be used to search for culprits, but will be used for learning exclusively.

6. Experience with SOL

SOL is listed as one of the standard methods of the International Atomic Energy Agency (IAEA) for the analysis of events in nuclear facilities (IAEA-TECDOC-1756). Furthermore, the SOL method is test winner in a comparative study on event analyses by the Federal Institute for Occupational Safety and Health (Fahlbruch & Meyer, 2013).

Since 2000, SOL has been the standard method for root cause analysis in all nuclear power plants in Germany and Switzerland and is held in high esteem by users. Furthermore, it is applied in the entire nuclear industry (research reactors, fuel production, fuel disposal, waste management) for the analysis of events. More than 250 employees from nuclear technology and other safety-relevant industries have already been trained by MTO Safety GmbH to perform an analysis with SOL.

VGB Powertech gave the following assessment of SOL: "By applying the SOL methodology, we have gained valuable insights that have led to improvements in organizational and administrative areas in particular. The SOL methodology has thus become an important tool for optimizing internal processes in our nuclear power plants.

A root cause analysis with SOL is easy and economical to carry out due to its limitation to 20 contributing factors. The systematic approach to an analysis with SOL (first event description, then search for causes) facilitates the application and reduces the susceptibility to typical errors of judgement.

The execution of an SOL analysis in a team with the participation of employees from production will improve the exchange of experience between employees and noticeably increase safety-oriented attention.

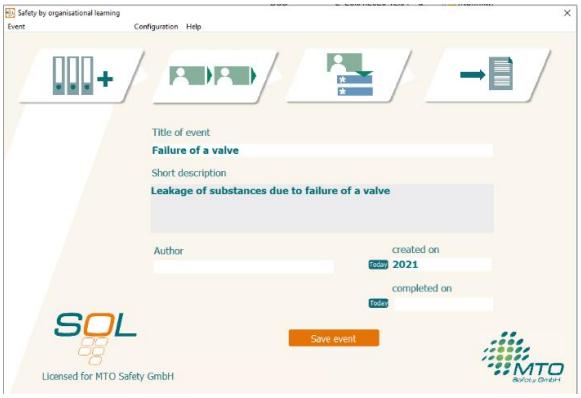
7. Software SOL

MTO Safety GmbH offers the SOL software for performing a SOL analysis. The software was developed with simplicity and good usability in mind. The SOL software runs on the operating systems Windows 7, Windows 8 and Windows 10 and is used in several nuclear power plants in Germany.

Graphically clear buttons help with orientation in the program flow. The arrangement of the buttons reflects the sequence of an SOL analysis: create event, define event modules, identify contributing factors, create report.

A variety of predefined lists and statistics can be generated directly from the SOL software. This helps in the creation of reports.

The software can be obtained from MTO Safety GmbH (www.sol-rca.de).



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