Bernhard Wilpert – The Father of SOL - Safety through Organisational Learning
by Gerhard Becker

SOL is a system for learning from events which is widely used today in the nuclear industry in Germany and Switzerland. It is the first system of this kind which was based on the Systems Theory. The fundamental ideas as well as the essential structure of the system have been coined by Bernhard Wilpert. It may therefore be interesting to follow the steps of its development, which is also evidence of the interdisciplinary work between psychologists and engineers (and other disciplines) which Bernhard loved and promoted despite all obstacles.

The story started in November 1989 at a World bank Workshop on Risk Management in Karlstad, Sweden, where we met for the first time. Bernhard presented a paper on the psychological and risk management aspects of the 1987 event at the nuclear power plant (NPP) in Biblis, Germany (primary cooling water had penetrated the reactor containment because of "human error"). I discussed the paper in the plenum from the perspective of an engineer based on my knowledge of the case. We had some fruitful talks in the framework of the conference and finally Bernhard proposed that we should stay in touch and try to do some research together concerning human factors in the nuclear industry. In the years after the 1986 Chernobyl disaster there was a growing realization throughout the world that the main lessons to be learned from the course of events in this disaster concerned human factors. The above mentioned event in Biblis had underlined this view.

But it took until January 1991 that Bernhard's idea formed shape. The German Federal Ministry of Environment and Reactor Safety (BMU) had decided to initiate human factors research concerning nuclear safety aspects. In order to discuss the initial proposals of BMU and to select the most important topics I had the task to organize a workshop with experts from science, the nuclear power plants, nuclear safety consultants, and BMU. Bernhard Wilpert had been invited as a prime representative of human sciences to this workshop which resulted in the selection of four topics seen as most relevant for research.

When the invitations to tender were published TU Berlin and TÜV Rheinland, Cologne, together prepared offers concerning two topics:

- Weiterentwicklung der Erfassung und Auswertung von meldepflichtigen Vorkommnissen und sonstigen registrierten Ereignissen beim Betrieb von Kernkraftwerken hinsichtlich menschlichen Fehlverhaltens. (Further development of the gathering and analysing of compulsory reportable incidents and other registered events in nuclear power plants, with regard to human failures).

- Analyse der Ursachen von 'menschlichem Fehlverhalten' im Betrieb von Kernkraftwerken. (Analysis of causes of “human failures” in nuclear power plants).

The aim of the first projects was to include human factors (HF) aspects in the official event reporting system and to encourage utility internal reporting of 'near misses' in which human behaviour played a role. The aim of the second project was to support event evaluation by the development of tools dealing with human behaviour which contributed to events. Reporting system and event analysis constitute the framework for organizational learning from events.

The offers presented to BMU with TU Berlin as main contractor of the first topic and TÜV Rheinland of the second one were successful and both projects started in spring 1992. Bernhard Wilpert prepared the work on these projects in his own inimitable way: He called well known experts in the field to contribute to a workshop concerning "Growth, Change, and Industrial Safety" in spring 1992 in his well known workshop series on "New Technology and Work" (NetWork). In the run-up to the workshop copies of reports of the meanwhile well known disasters like "Herald of Free Enterprise" and "Clapham Junction Railway Accident" were distributed among the experts invited, which provided a sound basis for discussing theoretical and practical questions of event analysis among the interdisciplinary group of experts. The results of the discussions delivered a good support to start the project work.

The two projects required a thorough review of the state of the art and a close interaction with German operators. The investigations in the German nuclear business covered interviews with power plants which prepare and submit event reports, authorities receiving the reports and the GRS (Gesellschaft für Reaktorsicherheit) evaluating the reports. Further, interviews were made with the simulator centre, a utility using a self developed system to collect and evaluate events, to which human behaviour had contributed, the VGB (Federation of the owners of large boilers) which serves as unit for the national and international exchange of operational experience between utilities and plants. The interaction with the power plants to study the practice in the plants was difficult in the beginning of the projects because the utilities feared new regulations Federal Government sponsored projects. But in the course of the work we interviewed about 60% of all plant managers and experienced trust by the plant representatives who allowed even one of the Berlin psychologists to have a two week training in one of the plants. Later on, representatives of all plants participated in workshops to discuss result of our projects. The interest in the topic of human factors in the nuclear arena grew fast after the start of the projects. As a signal that the topic came into the focus of the operators was the decision of the Committee of Plant Managers to set up a working group on human factors (HF) in the beginning of 1993 embracing HF-representatives of all German plants. This implied that HF-representatives had to be nominated and trained in each plant because only few of the plants had such expertise available.

The interview results obtained and the material collected showed a great variety of reporting systems and a number of event analysis methods applied in different industries. 10 out of 30 reporting systems collected have been selected for detailed review because they seemed to cover HF-aspects. About 30 practices for event analysis in various countries have been screened from which 11 methods were selected for review. Bernhard Wilpert and his team developed a set of criteria for the reviews applied to reporting systems and event analysis methods as well. These criteria included usual ones like validity, reliability, and objectivity but also theoretical adequacy and comprehensiveness, economy and practicability. The results of the reviews showed that most of the event reporting systems and evaluation methods had deficiencies concerning theoretical foundation and covered only parts of the factors which could contribute to events.

The results of the interviews in German NPPs revealed that event analysis was usually based on engineering judgement and expert knowledge of the plant systems and not aided by tools supporting the analysts.

In face of this experience we realized that the development of a new event analysis system seemed necessary which should enclose all relevant factors contributing to events. This system should be linked to the established event reporting (which itself should be extended) to enable organisational learning. Bernhard Wilpert suggested to base the system on the axioms of the sociotechnical systems approach (STSA). STSA was developed already in the 40s at the Tavistock Institute of Human Relations in London and has demonstrated its validity and usefulness over more than four decades (Trist & Bamforth, 1951; Emery & Trist, 1960). The system boundaries to be defined for our system enclose all parties which contribute to safety and reliability of the nuclear plant. Bernhard's team developed a diagram to illustrate the system which links five subsystems to each other: Technology - Individual – Team - Organisation and Extra-organisational Environment (see Fig 1).

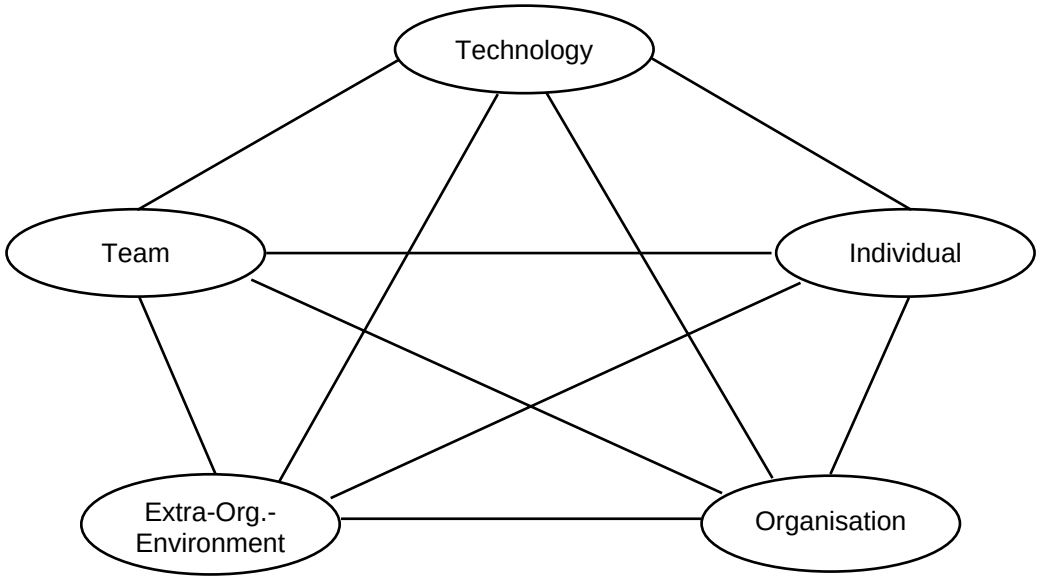

Fig 1. Sociotechnical Systems Approach – The five subsystems and their interfaces

A second methodological approach is connected with Jim Reason's metaphor of "latent error" (Reason, 1990) illustrating that in highly complex work systems, such as a nuclear power plant, where we have system designs based on defence in depth principles, a serious accident can never be caused by any single operator error (the active error) but that a number of concealed failures must have contributed which became obvious in the event. Reason has illustrated his idea with the "Swiss cheese model" (see Fig. 2). It was Bernhard Wilpert's way of thinking to combine these models in a socio-technical event causation model.

The event analysis process has been understood as a retrospective problem solving task intended to discover contributing factors to the event originating from the various subsystems or levels of the STSA. The concept developed (which later was called SOL) standardizes the process of the event analysis and not the content categories of the analysis. The analysis system developed included a situational description of the course of the event clearly separated from the analysis identifying the contributing factors, the development of countermeasures and the report of the results. The reported results should be coded, stored and distributed within the official event reporting system (respectively the internal system of the plant operators concerning e.g. near misses). Together, event analysis and event reporting system constitute the Organizational Learning System postulated by SOL.

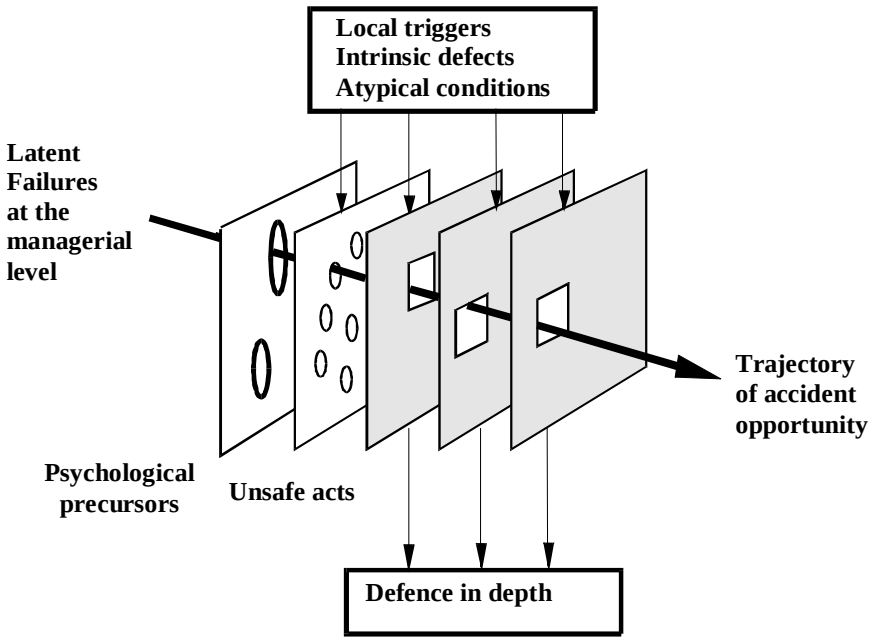

Fig. 2: The dynamics of accident causation (Reason, 1990)

The search for contributing factors should be performed by a qualified team of plant personnel with different background and experience. The analysis team should receive special training in human factors concerning the various perceptual biases threatening the event analysis (hindsight bias, strong but wrong early beliefs, etc.). An identification aid to support the process of search for contributing factors has been developed to support the problem solving task of the analysis team. This aid which in its initial form was called "search grid" contained keywords which in an exemplary fashion described items belonging to the five subsystems of the STSA. This approach leaves room for creative search for contributing factors based on the expertise of the analysis team. It avoids the limitations associated with the more mechanical path through an error/failure tree like MORT or a checklist aided procedure like HPES.

In a first step to validate the concept developed we searched the discussion with the practitioners of some nuclear power plants and presented the results of our projects in a workshop with representatives of all German nuclear power plants. To ensure frank and open discussion, Bernhard Wilpert convinced the representatives of the Federal Office for Radiation Protection (BfS) which guided our projects on behalf of BMU, not to participate in this workshop. (It was not an easy task to convince these people about methodological necessities). The fruits of this workshop were on the one hand a number of stimulations to enhance our proposals and on the other hand the realization that the persons involved in event analysis in the power plant saw themselves not in the position to handle items from the subsystem organization and organizational environment. However, this meant as well that the group of HF-experts from the plants finally became convinced that all factors of the STSA have to be taken into account in the event analysis.

To sum up, the first of the two projects delivered the details of a proposal for a three-stage reporting system including the mandatory event reporting, company confidential internal (HF-)reporting of events based on voluntary statements of plant personnel and a yearly summary report to the authority about lessons learned from the voluntary (HF-)reporting. The second project delivered the essential design of a new event reporting system to be used in connection with the reporting systems mentioned before; both together intended to enhance organisational learning from events.

It became evident at the end of the two projects in 1994, that further development of the tools for event analysis seemed desirable. Therefore, a follow up project has been designed and conducted by Bernhard Wilpert:

> Umsetzung und Erprobung von Vorschlägen zur Einbeziehung von Human Factors (HF) bei der Meldung und Ursachenanalyse in Kernkraftwerken (Implementation and

testing of proposals to include human factors in the reporting and analysis of events in nuclear power plants).

The proposal included several workshops with practitioners from the nuclear power plants, the step by step development of analysis aids, testing and validation of the aids. Finally, introductory conferences with plant representatives and the state authorities responsible for the inspection of the nuclear plants had been planned.

The Committee of Plant Managers had agreed that several meetings with the HF-practitioners from the plants could take place. But the discussions during the meetings became very difficult and might in retrospect be described as a series of battles. The cause for these problems resulted from the fear of some of the operators that applying our tools would give authorities an occasion to shut down their plants. This fear was expressed by plant representatives who belonged to Länder (states) in which the government intended to abandon the nuclear energy option. But the series of workshops to iteratively improve the SOL system has been continued and was not abandoned despite of all difficulties. A major reason for the continual readiness for the cooperation of the operators was that Bernhard Wilpert was a member of the German Reactor Safety Commission (RSK). He had been invited to be a member of this commission just after an interview with leading governmental officials of BMU in 1992 in the course of our research projects. Bernhard Wilpert gained fast a reputation in this Commission. He organized for example a commission internal conference concerning safety culture with international scientists and experts and influenced the thinking of the commission to a large extent. Some plant managers were also members of the RSK and this provided for sustaining cooperation in our research projects.

There are various further details to be reported on the progress of the project concerning the implementation of SOL. Bernhard Wilpert and his team organised a NeTWork-workshop on event analysis during the period of the ongoing project with well known scientists in the field which allowed for discussion of SOL and resulted in the well noticed book “After the event – from accident to organisational learning” (Hale, Wilpert & Freitag, 1997). A further project resulted in the development of a computer-based version of SOL.

The success of the SOL system was finally initiated by its introduction in the NPPs in Switzerland. Representatives of the Committee of Plant Managers reported of the good experience they had made with the system; this led somewhat later to the decision to apply SOL in all German NPPs.

References

Emery, F. E. & Trist, E. L. (1960). Socio-technical systems. In Churchman, C. W. & Verhulst, M. (Eds.), Management, Science, Models and Techniques (Vol. 2). New York.

Hale, A., Wilpert, B. & Freitag, M. (1997): After the Event - From Accident to Organizational Learning. Oxford: Elsevier Science

Trist, E. L. & Bamforth, K. W. (1951). Some Social and Psychological Consequences of the Longwall Method of Coalgetting. Human Relations, 4, 3-38.

Reason, J. (1990). Human Error. Cambridge: Cambridge University Press.