

# Safety Management Systems, Safety Culture and Resilience engineering: Comparison of Concepts

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## **Abstract**

Over the last decades major accidents occurred in the high reliability industries. This happened despite most of concerned companies strived for sophisticated safety management systems and many of them proclaimed a high level safety culture. Highly qualified employees and compliant, rule conform behaviour are generally regarded as core elements of safety management and culture in such companies. Probably this helped to decrease the number of “usual” occupational accidents. But are these classical approaches sufficient to prevent “extraordinary” incidents and accidents? The concept of resilience engineering delivers new perspectives on safety: The objective is to create organisations, which can compensate disturbances without loss of control and can quickly get back into safe balance. Flexible ways to act and decide and to avoid blind following of rules are important aspects of resilience. On one side this seems to be a smart way to reduce organisational shortcomings, on the other side it is not easy to develop solutions and measures which could be implemented in praxis. The objective of this study is to analyse concrete possibilities how to develop organisations with already existing safety management systems and established safety culture further towards resilient organisations.

## **Concepts and questions**

The fact that there is still a risk in every high reliability organisation which somehow seems to be out of control leads to efforts to improve the safety of systems and prevent similar accidents from happening again (Hollnagel, Woods & Leveson, 2006). Resilience engineering appears as a promising new approach: “In contrast, resilience engineering tries to take major step forward, not by adding one more concept to the existing vocabulary, but by proposing a completely new vocabulary, and therefore also a completely new way of thinking about safety” (Hollnagel, Woods, & Leveson, 2006, p. 2).

However, for many scientists, resilience in general is an old concept with a new name and refers to well known safety related issues (Morel, Amalberti & Chauvin, 2009). But the authors state, that “the relationship between resilience and safety is much more complex than a simple, cumulative way of improving safety” (Morel, Amalberti, & Chauvin, 2008, p. 3). Sheridan (2008) states that resilience is “a family

of ideas” which has been defined in many different ways. He too argues that many aspects of resilience were already known under different names.

It is very clear that there is close relation between safety culture concepts and resilience. Modern safety cultures in big companies require safety awareness at all organisational levels and continuous loops of learning and improvement of safety procedures. Safety management systems require the strict conformity of behaviour with existing rules and regulations. Somehow as an antipode, there is the big challenge of resilient systems to define room to manoeuvre and to avoid blind following of rules. On one side this seems to be a smart way to reduce organisational shortcomings, on the other side it is not easy to develop solutions and measures to be implemented in day-to-day routines. Sheridan (2008) identified this problem of application already. Altogether there is still a clear lack of proven and transferable methods.

This study seeks to address the following questions: (1) what is new about resilience engineering, (2) how widespread is the concept of resilience engineering among safety managers in Germany and (3) how can an organisation with an existing safety management system and an established safety culture be developed further towards a resilient organisation.

The next section gives a comparison of the concepts of safety management systems, safety culture and resilience engineering and illustrates similarities through a systematic analysis. Information on the second question is gathered through expert interviews which indicate the additional benefit of resilience engineering for companies. Question three is picked up in the results section.

### **Comparison of Concepts**

Resilient systems strive for the recognition of unforeseeable situations, compensate interruptions and get back to a safe state after the case of emergency. It is typical for such systems that different organisational elements interact in a complex and dynamic way. A generic understanding of individual and organisational resilience integrates aspects from different theoretical approaches like salutogenesis, information processing and learning organisations (Kastner, 2010). The important goal is to give employees, work teams, organisational systems and networks of companies, room to manoeuvre to act flexible in unexpected situations. This is achieved by providing them with resources and mechanisms of compensations. Reviewing the literature on resilience engineering shows that the most important indicators of the implementation level of the concept are:

1. Top-level commitment
2. Allocation of sufficient resources
3. Flexible scope of action
4. Safety awareness, transparency, process of learning

In addition to the requirements of safety strategies and goals, the top-level management has to prioritize safety over efficiency in order to allocate necessary resources to employees to act right and effective in critical situations (indicators 1 & 2,

MacEachen et al. 2008, McManus et al. 2007). The aim is to take pressure from the employees resulting from the dilemma of thoroughness and efficiency (Hollnagel, 2009) in order to allow a flexible scope of action within safety boundaries.

Indicators 3 and 4 foster safety awareness to recognise critical situations and the identification of the right thing to do even beyond safety regulations. Boundaries for the scope of action have to be created and measured to improve situation awareness and to enable flexible acting. This could furthermore support work teams, so consequences of failures are not added up but can be compensated.

*Table 1: Comparing common categories and characteristics of safety management, safety culture and resilience engineering*

Approach	Safety management	Safety culture	Resilience engineering
Indicators			
Commitment of top-level management	Defined goals on occupational safety and health issues as well as principles of prevention	Safety awareness on all levels of the organisation, safety philosophy described, allocation of necessary organisational structure	Clear instructions for safe decision making
Resources	Management of resources as a responsibility of top-level management, standards based on estimation of necessary resources	Provision of resources as a leadership task, conflicts between efficiency and safety are decided in favour of safety	Allocation of resource buffer for critical situations
Flexible scope of action / compliance	Compliance with safety regulations, observation of compliance	Promotion of safety awareness on all levels	Definition of a room to manoeuvre when it comes to safety relevant decisions
Continuous process improvement	Audits, frequent revisions	Measuring and learning, culture to report failures and near misses	Proactive identification of possible failures, identification and promotion of safe, good practices

Currently, the resilience engineering approach is preferably used in the field of air traffic control systems (Malakis et al., 2010), focussing economic and safety goals. In the context of occupational safety and health, the resilience engineering concept is quite new and the discussion is currently in progress. To assess differences and similarities between resilience engineering and established approaches like safety

management systems and safety cultures, we used the indicators of the resilience concepts listed above. This works because all of these aspects are already addressed somehow in concepts of safety management and safety culture. Table 1 shows a comparison focusing on leadership, resources, flexibility and continuous process improvement.

The analysis of the three approaches shows progressive requirements on leadership, resources, flexibility and improvement. Therefore, the approaches of safety management and safety culture could be complemented by the requirements of resilience engineering (Olive et al. 2006; Fahlbruch et al. 2008). A special aspect of resilience engineering which should be emphasized is the consideration of leading safety indicators with the elements “measuring” and “learning”, which is discussed and recommended for plant safety management systems (KAS-7 2005, Costelle et al. 2009, Steen and Aven 2011). A challenging aspect could be related to the requirement “compliance” and “room to manoeuvre”. More specifically, it has to be clarified, within which limits and under which conditions employees are empowered to derogate from standard operating procedures or instructions. Clarity must exist on persons who can make decisions and who should be involved in the decision-making process. Based on the theoretical analysis and the assumption that the new aspects of resilience engineering could be integrated into current modern safety managements systems and safety cultures, the following questions arise:

- What do companies know about resilience engineering?
- Do they have already discussed resilience engineering in their organisation?
- How do they think about it, do they think it could improve their safety performance?
- Do they have special work pressure due to external influences?
- Do they think that they could have unpredictable situations and do they relate this to a need for more room to manoeuvre for employees?
- Do they have instruments or concepts to “integrate room to manoeuvre” in their safety management system?
- How could their current safety management systems be improved?

### **Method**

Semi structured interviews were conducted to collect data on the questions listed above. The 13 participants were safety experts working in different branches (e.g. chemical industry (n=8), oil industry (n=2), pharmaceutical industry (n=2), automotive industry (n=1) in Germany. All surveyed enterprises had more than thousand employees.

As a first step, companies which report to have well developed safety management systems / safety culture in place were listed and their leading safety experts were identified. Then a message was sent to these experts and they were informed about the intended interviews. After fixing dates, telephone interviews were conducted. All

interviews were done by the same interviewer; notes were taken during the interviews. The interviews took between 10 and 50 minutes.

Table 2: Extracted opinions about resilience engineering (re) split into three types of companies

Level of experience	Companies without expertise in re (n = 2)	Companies with some expertise in re (n = 7)	Companies, who already introduced measures to increase re (n = 4)
Aspects			
General opinion	Resilience approach can be useful and important, but is currently not pursued; external influences are managed with conventional methods like supplier audits	External and internal influences force the company, managers and operators to be flexible in order to adapt to new conditions; resilience is therefore a useful approach; existing instruments have to be extended	Companies have already arranged a campaign to support flexible scope of action; it is not always named resilience but for example “responsible handling”
Improvement of safety management and safety culture	Currently there is no plan for improvement	Improvements happened punctual for example based on lessons learnt; they are not done on all levels of hierarchy	Safety management and safety culture are continuously improved especially based on failure detection, risk assessment and lessons learnt
Unpredictable situations	Only well-known scenarios are discussed	Safety rules for the operators include only general instruction with enough latitudes	Unforeseen situations have already happened; flexible scope of actions with concrete boundaries are in place and helped to stay safe
Instruments and measures to enable and stimulate flexible handlings	Actions on the basis of safety rules are required; in other situations a emergency plans are executed	On the basis of scenarios risks are identified; discussions of infrequent incidents are mandatory.	Improvement of plant safety on the basis of holistic risk assessment: What happened, where should we allocate more resources? Lessons learnt are used to improve safety culture; operators are invited to question regulations and if necessary to suggest solutions; the aim is to empower operators and teams to increase their situation awareness

## Results

The following three categories were created from the data retrieved from the interviews: (1) Companies without expertise in resilience engineering, (2) companies with some expertise in resilience engineering and (3) companies, who already introduced measures to increase resilience. Answers were abstracted and structured and are reported for each category (table 2). Based on the results it is not possible to identify unique factors which allow a prediction to which category a company of a certain size or branche is assigned.

## Discussion

A positive feedback towards the ideas of resilience engineering can be deduced from the interviews conducted. All of the participants showed interest in the concept of resilience engineering. They gave substantial answers to every question. But there are also critical votes against resilience engineering, which indicate constraints of this approach.

Companies without expertise in resilience engineering share the goal of responsible care and safe behaviour, but did not report resilience engineering to be an urgent issue to improve their safety management systems or their safety culture. In their opinion, safety must be observed and critical situations must be managed by the safety and emergency teams. These experts point out that the companies have standard production processes and rarely external influences, which require flexible actions. As stated above, it is not possible to identify “hard factors” like size or branche which may reveal a trend towards the implementation of resilience engineering. It rather seems that “soft” factors like opinions on safety play a considerable role on the willingness to turn to the concept of resilience engineering and reconsider rigid standard processes.

The “few” disturbances are managed within the scope of emergency control. Within the emergency procedures, behaviours in critical situations are trained.

Participants from companies with some expertise in resilience engineering or companies, who already introduced measures to improve resilience, see the need for clear boundaries for these rooms to manoeuvre and self responsible behaviour. Most experts state, that safety management should be continuously improved to recognize critical situations as early as possible. But normally after accidents new safety rules are created, which limit the rooms to manoeuvre. Guidelines with detailed work steps to create instruments for resilience engineering were missed and would be regarded as helpful.

The analysis shows that modern safety management systems and safety cultures make already a substantial contribution to the resilience of organisations and occupational safety and health. Nevertheless it needs to be discussed, how the strategy of flexible scope of actions to cope with unpredictable critical situations can be realised in the practical work. At the end the most important question seems to be: How can

the conflict between compliance with safety rules and flexibility of behaviour be solved?

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