

Proactive and flexible safety management – resilience in Finland

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Abstract

Production and service systems have developed more complex because of increase of their size, networking and globalization. It has been claimed, that in such complex socio-technical systems, accidents can not be explained with linear models based on failures. Accidents can be seen as an unexpected combination of conditions and events. Performance variability is inevitable and necessary in complex systems. Therefore, a new systemic approach called *resilience engineering* is being developed for safety management. A study was carried out, in which the resilience engineering approach and its appearance in Finnish industry was explored. The focus was on the prevention of occupational accidents.

This paper presents results of the interviews of industry representatives and an expert workshop. The required qualities of a resilient system formed a framework for the study. These qualities include: anticipation, attention (monitoring) and response. In companies, anticipation – knowing what to expect – typically consists of different means of risk assessment; in some cases concerning every new task to be started. Attention – knowing what to look for – is advanced with audits, observations, near miss reporting and benchmarking. Response – knowing what to do – is typically based on action plans, related training and reserve resources. In general, experienced people are used in cases, where problems appear or are expected. Besides the knowledge, the motivation of employees at all levels is important for resilience and different means to motivate personnel are utilized.

The key difference between the traditional safety management and the resilience engineering appears to be related to the view on flexibility. The traditional safety management sees strict instructions and rules important and deviating from them is prohibited. Resilience engineering sees awareness of the situation and flexible response necessary as well. The challenge is how to combine these two aspects in practice.

Keywords:

Resilience engineering, safety management, accident prevention, occupational safety, industry

Introduction

Production and services have developed and are still changing to more complicated. At same time

the interdependencies of different players are increasing, when network activities and sites are growing.

We can say with good reasons, that the multidimensional and strongly interactive activities can not be controlled by pure traditional way which is aiming to restrict errors. The socio-technical systems are so complicated, that they can not be analysed by traditional risk analysis dividing system into parts and by identifying not wanted chains of events (Hollnagel, 2007).

A research was carried out to study, how safety management at enterprises can be improved by introducing new proactive and flexible approach (resilience) to it.

The main research questions of the study were:

1. What is proactive and flexible (i.e. resilient) safety management?
 - What are typical features and practical manifestations of it?
 - How it differs from the traditional way and how it completes the traditional way?
 - What kind of practical tools and operations models are needed?
2. What practical manifestations of proactivity and flexibility (i.e. resilience) we can find from present working methods and what is lacking?

The term Resilience Engineering represents a new way of thinking about safety. Whereas conventional risk management approaches are based on hindsight and emphasize error tabulation and calculation of failure probabilities, Resilience Engineering looks for ways to enhance the ability of organizations to create processes that are robust yet flexible, to monitor and revise risk models, and to use resources proactively in the face of disruptions or ongoing production and economic pressures.

In Resilience Engineering failures do not stand for a breakdown or malfunctioning of normal system functions, but rather represent the converse of the adaptations necessary to cope with the real world complexity. Individuals and organizations must always adjust their performance to the current conditions; and because resources and time are finite it is inevitable that such adjustments are approximate. Success has been ascribed to the ability of groups, individuals, and organizations to anticipate the changing shape of risk before damage occurs; failure is simply the temporary or permanent absence of that. (Resilience Engineering, 2010)

Hollnagel (2008) has defined, that resilient organisation should have following features:

- It can *respond* to regular and irregular threats in a robust, yet flexible, manner. The ability to respond focuses on the actual and is a quality found in all industrial systems, although in varying degrees. No system can, however, survive without being able somehow to respond when something goes wrong. Many systems, however, have a limited range of responses or are unable fully to adjust their responses to meet unexpected demands.
- It can flexibly *monitor* what is going on, including its own performance. The ability to monitor focuses on the critical, i.e., on that which may happen in the next moment or the near future such as disruptions or sudden changes in demands or resources.
- It can *anticipate* risks and opportunities in the longer term, i.e., it can keep an eye on the potential. To do so requires both a certain level of imagination and sufficient resources in terms of time and/or effort. Anticipating what may happen must go beyond the classical risk assessment, and consider not only individual events but also how they may combine and affect each other.
- It can *learn* from experience, i.e., focus on the factual. Learning requires more than collecting data from accidents, incidents, and near-misses. Data are relatively easy to amass

as a routine or procedure, but experience requires the investment of considerable effort and time in a more or less continuous fashion.

This Hollnagel's description of features of resilient organisation formed the basic framework to the study of the second question, concerning the manifestation of resilience in current practices of Finnish industry. To strengthen the human aspect, another dimension including capability, motivation and conditions were added to the framework. Capability represents required knowledge and skills; motivation means willingness to act in certain situation; and conditions are all physical factors (e.g. resources and environmental factors) that enable or disable action when required. The elements of the framework used in this study are summarised in figure 1. This paper presents results of the interviews of industry representatives and an expert workshop which aimed to define key factors of resilience and practical manifestations of resilience in Finnish industry.



Figure 1. Framework to analysis of resilience enhancing properties

Material and methods

Interviews

In this study, interviews of industry representatives were carried out and an expert workshop was arranged. Representatives of four companies were interviewed. The companies operate in construction, construction materials industry and metal industry. The interviewees consisted of a deputy managing director, development director, a plant manager, a production manager, a QEHS-manager, QEHS-engineer, 3 safety managers, a safety specialist and 2 industrial safety delegates. Groups of 2-4 persons were interviewed by two interviewers at the time. Interviews were carried out by 4 experienced safety researchers.

Questionnaire for interviews was developed on the basis of the evaluation method presented by Johansson and Lindgren (2008). The method is intended for evaluation of resilience enhancing properties of organisation. In questionnaire, these resilience enhancing properties were complemented by the ideas about personal level resilience presented by Komatsubara (2008). The topics of the questionnaire are presented in table 1.

Table 1. Topics of questionnaire

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|---|
| <ol style="list-style-type: none">1. Resilience enhancing properties – detection<ol style="list-style-type: none">1.1. Capacity to predict changes in the process or environment1.2. Possibilities of detecting differences between normal (desired) and non-normal (undesired) states.1.3. How are detected problems disseminated within the system/organisation?1.4. Time available to be able to identify unwanted events
2. Resilience enhancing properties – adaptation<ol style="list-style-type: none">2.1. Possible states available (shutdown possible, “graceful” degradation possible, emergency states available, reversibility etc)2.2. Potential for controlling variables<ol style="list-style-type: none">2.2.1. External variables2.2.2. Other (internal) variables2.3. Willingness in organisation to temporarily relax the efficiency goal for the safety goal when circumstances suggest going so2.4. Willingness in organisation to temporarily deviate from regulations when circumstances (ensuring safety) suggest doing so2.5. Resource preparedness, availability of resources2.6. To what degree does employees understand the organisation and overall system functioning2.7. Potential for learning from past experiences.2.8. Functional redundancy2.9. System and organization individuality
3. Personal level resilience<ol style="list-style-type: none">3.1. Technical skills of employees (including safety skills)3.2. Non-technical skills of employees (awareness of situation, decision making, communication)3.3. Attitude to problem solving (positive and active vs. passive). |
|---|

The main question groups 1 and 2 (table 1) were almost directly adapted from Johansson and Lindgren (2008). However, related specific questions were developed for each subtopic (originally in Finnish). For example, the actual questions related to topic 1.2 were: *Differences in normal and undesired states: What kind of undesired states there could be in your process? Are the criteria for the normal and undesired states defined? Is there lot of variation in the normal state?* And the questions related to the topic 2.4 were: *Are there strict and extensive instructions for activities? How precisely the instructions are actually followed? How closely it is monitored and supervised that the instructions are followed? When there are no instructions, on what basis the action succeeds? Are the instructions sometimes deviated from in good reason? How the deviation from instructions has been handled?* And the questions related to the topic 3.3 were: *How employees act in the situations where active problem solving is needed? Is the activeness of employees favourable (when it is? when it is not?) How the activeness of employees is tried to be directed? How the activeness or passiveness affects to safety?* The questions were developed by the research team.

In the beginning of the interview, the meaning of the research project and the concept of resilience was introduced. The questionnaire was not shown to the interviewees. A semi-structured interview method was used, though the specific questions had been developed, as presented above.

The interview results were analysed mainly on the basis of the notes written during interviews, although recordings also were available. The framework presented in Introduction chapter was used to identify features, which would reflect the resilience the organization. As a result, a resilience engineering appearance in these Finnish companies was described.

Workshop

A one-day workshop for experts from enterprises, research institutes, universities and authorities was organized. The aim of the workshop was to discuss the components of resilience engineering and to examine how resilience engineering could be applied in practice. The workshop discussed opportunities and risks related to the concept of resilience, how does it appear in practice and how could it be applied at workplaces. The workshop consisted of presentations, group work and general discussions. The number of participants and the organisation type they represented are presented in table 2.

Table 2. Participants of workshop

Organisation	Number of participants
Enterprise (Safety and health experts)	9
Research institute	9
University	3
Authority	2
Insurance company	3

Results

Interview results – resilience in Finnish industry

The concept of resilience was unknown for nearly all interviewees. The results on interviews were analyzed according to the required qualities of a resilient system presented by Hollnagel and Woods (2006). These qualities include anticipation, attention, response and learning. Actually the results describe resilience enhancing properties of the system (as Johansson and Lindgren, 2008, formulated it) rather than resilience itself. That is, the arrangements and practices which enhance anticipation, attention (monitoring) and response are described. The aspects of capability, motivation, and conditions are also studied in relation to these “qualities of resilient organization”

Anticipation

The concept of anticipation is quite confusing in resilience engineering: The classical way of risk assessment (“traditional anticipation”) is criticized as an inefficient tool in modern systems which are complex. On the other hand, a clear model of “resilient anticipation” has not been introduced. However, an availability and use of hazard identification and risk assessment tools can be seen at least as a starting point for anticipation. Different risk assessment tools are quite widely used in companies in this case. Since resilience engineering points out the complexity and dynamic nature of systems, it can be argued that the more real time and local the risk assessment is, the more resilience enhancing it is. For example, in construction this means several different risk assessment activities during the whole designing, planning and building process; and risk assessment and replanning in building phase even on daily basis and task by task. Understanding of system’s behaviour and hazards can be seen as preconditions to anticipation. The information about incidents are collected, analysed and communicated in many companies. However, it could not be examined, if this information is used to improve organization’s understanding in such way that it would enhance capability to anticipate.

Motivation to anticipate or “anticipation culture” is related to general safety climate of organisation and whether the anticipation is as possible and useful. Culture of looking backwards is quite strong in many organisations – especially concerning safety. For example, key indicators typically are reactive such as number of injuries. General safety culture of the organisation is naturally basis for all resilience engineering activities. In one case especially, it was stressed out, that persistent, visible and even strict safety development has finally also improved safety climate of the organisation. An active safety organization which has *courage* to question practices was seen as strength. The active work of line management in favour of safety activities was presented as an effective means to ensure employees, that safety really is something worth to work on. This is especially important in anticipation (or risk assessment) activities where the optimum result is that “nothing happens”. Thus, the practical usefulness of anticipation can easily be doubted.

Possibilities to anticipate varies a lot depending on the system and it’s environment. For example a construction site changes much more rapidly and extensively than a typical industrial production site. This makes anticipation work at construction site more laborious requiring more resources – mainly time. This is typically the most limited resource – especially in construction – which makes its allocation to safety even more important. Another, simpler example is the normal variation of the quality of raw material for metal production, which may cause safety problems in production process if not anticipated.

Attention (Monitoring)

According to Hollnagel and Woods (2006), the basis for attention is to know what to look for. Organisations monitor their safety situation and development by many different means, e.g.: injury and incident statistics, incident investigations, safety and housekeeping observations and audits, technical inspection, health examinations, benchmarking etc. Are these what they should look for? Again, since the systems are dynamic and complex, the monitoring focusing on gathering and using information about the situation at the moment should be more resilience enhancing, than looking backwards (e.g. injury statistics). Safety observations and audits (including near miss reporting), when they are carried out extensively by employees, (may) enhance resilience at floor level by focusing employees attention on hazards and current situation on site. These kinds of procedures are in use in industry. On the basis of same information, attention could possibly be directed on more profound changes affecting to the organisation. This would require a procedure and tools, which were used to analyse the information properly and rapidly. For example, procedures for organisational learning from incidents have been developed. However, well working examples of such procedures were not found in industry.

An organisation culture which truly relies heavily on working instructions and rules, may suppress employees capability and motivation to pay attention to situation and unexpected changes. This assumption could not be confirmed in this study. Nonetheless, it was expressed as inevitable that detailed instructions can not be written for every tasks, and, further, that procedures should be called into question and that rules need not to be obeyed, if ensuring safety in the situation requires it. Usually an approach to rules and instructions is stricter in industry, but this more “resilient” viewpoint was also found. Simple examples on how attention in certain periods can be directed at floor level are warning about slipperiness at winter time and informing about the incoming low quality raw material, which may cause problems. In general, organisations are paying attention to situations, which are somehow new or demanding, like new kind of construction tasks or projects. In those situations, capability to anticipate, monitor and respond have typically been enhanced by nominating experienced people in charge. That means people who have experience on many

different tasks or projects, even though not necessarily experience on just that kind of tasks or projects.

Response

Ability to respond can be defined as, how well unexpected variation or expected variation at unexpected moment can be handled in order to minimize harm. It can be assumed, that the ability to respond to unexpected depends on, how tightly production and control systems, procedures resources organisation are designed and allocated according to the planned operation and the expected variation only. The tight focusing on expected, may limit ability to respond to unexpected. The idea of lean production has become very popular in industry. “Lean production is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination” (Wikipedia, 2010). In the resilience point of view, there is a danger, that organisation will be developed as too “lean”. As an opposite example, in the construction industry case, the safety budgets and the time and personnel used to safety issues are not as tightly controlled as for other purposes. It is meant to reduce an unwanted effect of efficiency philosophy – “lean” or other – on safety, and it creates better basis for anticipation, monitoring and protection against known hazards. Nonetheless, it does not improve an ability to respond, except indirectly by improving the safety climate of organisation and thus, the motivation to respond. The motivation to respond or “responding culture” may be utterly important in situations, when it is not clear, whether or not (and how) it should be responded. One example on how to enhance rapid response, is the practice to reward everybody, who stops the production line to prevent an accident – whether or not it afterwards appeared to be necessary.

In situations, when especial capability to respond is predicted to be needed, the capability is enhanced by using experienced persons – as noted before. In certain case, for example, there have been problems in maintaining ability to respond: Because the process has been gradually improved as virtually stable, new operators have not learnt and old ones are in danger to forget, how to handle severe disturbances of the production process. Still, the possibility to severe disturbances remains. Professional skills in general and personal suitability to task and situation were seen the main contributors to ability to respond. Professional skill in this case should also include understanding, not only technical skill. As an example of personal suitability it was noted than there are some so terrifying disturbance situations in the process, in which everybody can not act rationally. People may have also physical or mental limitations, which should be taken into account. Understanding of whole production system and organisational processes is also supposed to improve the ability to respond rapidly and correctly. For example, regular changing of duties is one way, which is used to increase both the experience and understanding.

Traditionally, ability to respond is especially ensured by emergency planning, which in some cases has been extended as continuity planning. Procedures for emergency situations are written, special equipment are purchased, acting and operations in emergency situations are trained and rehearsed. In many cases, there are plans and practices to ensure availability of key persons and sufficient (critical) manning in every situation.

Learning

How to learn to anticipate, monitor, respond? Organisations have brought in or developed several means by which their suppose to anticipate, monitor and respond (some examples mentioned above). Since the systems and environment are continuously changing, the adequacy of the means should also be continuously evaluated and improved – especially because the current means not yet necessarily take the resilience viewpoint into account. In industry, different procedures for continuous improvement are used. Above mentioned lean production philosophy is one

implementation of the continuous improvement idea. However, continuous improvement practices usually tend to focus on (short term and undisturbed) efficiency of the system and not on resilience. So, in the resilience point of view, this kind of continuous improvement may be even harmful.

One kind of organisational learning is development of safety culture and climate. This also forms a basis for the resilience of the organisation. The active visible leadership by line management and concrete safety interventions were seen as effective contributors in safety culture and climate development.

On personal level, comprehensive understanding of system and organisation functionalities, multiply skilled personnel and experience on different critical situations were considered resilience enhancing properties. These can be learned, for example, by working in different tasks in the organisation. On the other hand, it was noted, that personal qualities may limit ability to act in certain situations, which limits ability to improve resilience by learning. Thus, selection of appropriate persons in positions and tasks was considered essential for resilience as well as for efficiency and quality.

Workshop results – key characteristics of resilience

The workshop identified key characteristics of resilience engineering (table 3). Anticipation and attention require possibilities to identify changes in processes and environment, predefined criteria for normal and deviating stages of processes and sufficient resources for identifying deviations. Efficient response requires flexibility of operations, procedures and decision-making. Management of change, process control and organizational learning are essential features of response. Resilience capability of personnel requires technical and non-technical skills that support understanding of the operation of the organization and system.

Table 3. Key characteristics of resilience as identified by the workshop.

Quality of resilient organisation	Key characteristics
Anticipation and attention in organization	<ul style="list-style-type: none"> • Changes in processes and environment are possible to be identified proactively • Normal and deviating stages of processes has been defined and their criteria are clear and observable • There are efficient procedures to spread knowledge on identified problems • There are sufficient resources for identifying deviations
Response	<ul style="list-style-type: none"> • Flexibility of operations, procedures and decision-making • Management of change • Process control • Organizational learning
Resilience capability of people	<ul style="list-style-type: none"> • Understanding of the operation of the organization and system • Technical skills that support resilience • Non-technical skills that support resilience, i.e decision-making, situational awareness, communication • Positive and active approach to solving different situations

Conclusions

The key message of resilience and critique directed to traditional safety management are clear and justified. The message and critique focus on difficulty to control dynamic and complex system. In spite of the clear message, new safety management solutions based on resilience engineering still are quite few. One aim of this study was to identify practical manifestations of resilience in industry. Resilience enhancing features were identified in existing general and safety management practices, even though the concept of resilience was unknown in industry. This was not surprising, on the contrary, this just confirms the argument, that a complex system does not work without resilience. As the conclusion of this study, it can be argued, that the resilience engineering already partly includes in existing management practices, but the idea of resilience engineering requires more dynamic, continuous and comprehensive practices (e.g. involving all employees). The true organisation level anticipation (other than traditional risk assessment) and organisational learning related to the resilience seems to be major challenges. Finally, resilience engineering seems to require a new, more permissive and even critical approach to instructions and rules, which traditionally have been the corner stones of safety management. This would mean a significant cultural change in safety management.

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