Applying the resilience concept in practice: A case study from the oil and gas industry

Lisbeth Hansson & Ivonne Andrade Herrera
SINTEF, The Foundation for Scientific and Industrial Research at the University of Trondheim

Trond Kongsvik
NTNU Social studies LTD

Gaute Solberg
StatoilHydro

ABSTRACT:This paper demonstrates how the resilience concept (Hollnagel et al 2006) can be used as a perspective for reducing occupational injuries. The empirical background for the paper is a case study on an oil and gas installation in the North Sea that had a negative trend in LTI (Lost Time Injury) rates. The HSE (Health, Safety, Environment) administration initiated a broad process that included the crew on the installation, the onshore administration and a group of researchers to improve the situation. Instead of focusing the analysis on incident reports, we applied a proactive view. Thus, we adapted a model for resilience that was used in a development process. In the context of occupational accidents, we focused on the following factors: sufficient time, knowledge and competence, resources and including working environment. These factors have been identified as important for complexity and necessary for the organization to be able to anticipate, perceive and respond to different constellation of conditions. This paper illustrates to what extent the concept of resilience was fruitful analytically and as a reflection tool in the development of new HSE measures that are now being implemented. The links between the resulting HSE measures and the qualities of the resilience concept are discussed.

1 INTRODUCTION

1.1 *Background*

The empirical background for this paper is a case study on an oil and gas installation in the North Sea. The starting point for the study was historical data that showed a negative trend in LTI rates. We as an outside research group were engaged in an effort to improve their prevention efforts. During our involvement we tried to shift the focus in the organization from a reactive to a more proactive view on safety. By using an action research approach (Greenwood & Levin 1998) we tried to disengage from the focus on the negative safety results and introduced resilience as an alternative concept for reflecting upon safety. More concrete, the research question we will try to illuminate in this paper is: How can resilience be built in practice in organizations?

Many different strategies are used in safety work in the oil and gas industry. What many of them have in common is that history is used to learn about the future. One example is accident investigations that are carried out to identify causes and implement measures to avoid similar incidents to occur. This is in line with an "engineering" approach to safety that Hollnagel (2008) name "Theory W". Basic assumptions here are that systems are tractable, and that systems should be designed to avoid variability that in it self is regarded as a threat to safety.

One problem with using historical data as an approach is that conditions that produce dangerous situations and safety conditions are both complex and dynamic. The complexity refers to the interdependency of causes and that a specific constellation of conditions often has to be present for accidents to occur. Thus, it is often difficult to reduce accidents to simple cause and effect relationships. The social and technological context in which accidents occur is also in constant flux and can be regarded as "moving targets" that are difficult to grasp through traditional accident investigations.

The resilience concept (Hollnagel et al 2006) represents an approach that implies building mechanisms that make the organization prepared for the unexpected. This can be regarded as a proactive approach to safety. In a proactive view individuals and organizations must adjust to cope with current conditions. These adjustments handle different constellations of conditions that can produce accidents and also successes. Thus a resilient organization (or system) can adjust it's functioning prior to or following changes and disturbances to continue working in face of continuous stresses or major mishap. Here,

variability is regarded as potentially positive for safety, in line with what Hollnagel (2008) label "Theory Z".

The study is limited to one installation, and can be regarded as a case study. This implies the exploration of a "bounded system" over time involving several data sources rich in context (Creswel 1998).

1.2 *The case: Heidrun TLP*

The case study was conducted on Heidrun TLP, which is an oil and gas producing installation in the North Sea. It is a large tensioned leg platform (TLP) built in concrete that has operated since 1995. When Heidrun was designed and built it was regarded as a North Sea "Rolls Royce" with sufficient space and high quality equipment. The personnel working on Heidrun are proud of the installation and feel a strong ownership towards their working place.

Heidrun TLP is operated by the largest petroleum company in Norway, StatoilHydro. Approximately 50 % of the workers on the installation are employed by StatoilHydro while the rest are employed in companies responsible for drilling and production, companies responsible for the maintenance and modification work and another company within StatoilHydro is responsible for the catering activities onboard. The personnel on the installation follows the ordinary work schedule as used in the offshore business, two weeks on and four weeks off duty.

The offshore industry has a high reputation regarding safety. The safety awareness is high among the employees and compared to other industries the statistics on occupational accidents are low. Still, the frequency of occupational accidents has increased during the last years, also on Heidrun TLP. This may be a consequence of multiple reasons but some of the causes mentioned are increased personnel turnover, more inexperienced personnel and a higher activity level caused by extended modification work. The contract personnel are more exposed to accidents than the StatoilHydro employees. One explanation for this is that the contractors are engaged in the most risky and complex operations. In general the work schedule in the offshore business is regarded as challenging for the workers; being away from normal life and the family for two weeks is one challenge and it is also challenging to change into a work mindset after four week off.

The approach chosen for the case study was action research combined with use of the resilience concept. In practice, this implied a mutual reflection in a search conference upon how to strengthen certain qualities that could make Heidrun TLP more resilient as an organization. The negative safety results were not addressed at all in the workshop. Instead we focused on the positive aspects of the organization and on how to strengthen these even further.

In the next part of the paper the resilience concept will be further explored, followed by a description of how the concept was used in our case. In part four, the results will be presented, while we in part five will give an overall discussion of the findings, followed by the conclusions.

2 THEORY: THE RESILIENCE CONCEPT IN SAFETY RESEARCH

The term resilience is not a new concept within safety. Foster (1993) defined resilience as an ability to accommodate change without a catastrophic failure, or the ability to absorb shock graceful. Rosness et al. (2004) adapted the resilience definition to the capacity of an organization to accommodate failures and disturbances without producing serious accidents. Resilience has also been defined as the properties of an organization to make it more resistant to its operational hazards (Reason and Hobbs 2003). The resilience engineering term has been discussed as a transition from "traditional view" to a "systemic view" of safety. (Hollnagel, 2007a)

In the traditional view, accidents are seen as a result of failure or malfunction of components (humans or machines). These failures follow a predefined path of cause and effect. Accident models and their metaphors provide basis for the prevention alternatives. Accident prevention recommendation based in the Domino Model (Heinrich, 1930) finds and eliminates causes of specific accidents, and allows responding to this specific unwanted event. In the same way, accident prevention recommendations based in the Swiss cheese model (Reason, 1990) focus on strengthen any barriers and defences. In the traditional view, risks are seen as a linear combination of cause and effect and safety is achieved by constraint variabilities.

Due to technological improvements there has been a transition from tractable systems to intractable systems. Sociotechnical systems are becoming so complex that work situations are always underspecified. The designers can not anticipate every contingency. These systems are no longer bimodal and normal performance is variable. In accordance with Hollnagel (2007b), performance variability is related to technological systems malfunctions, imperfections and to the humans that have the tendency to adjust to current conditions. Therefore, the performance variability of the sociotechnical systems is normal and necessary resulting in both successes and failures. In the systemic view, accidents and incidents are the result of unexpected combinations of normal performance variability. Accidents are prevented by monitoring and damping variability. In this view, risks emerge from non-linear combination of performance variability.

Hollnagel (2008) defines formally resilience engineering as the intrinsic ability of an organization (or system) to adjust its functioning prior to or following changes and disturbances to continue working in face of continuous stresses or major mishaps. It is not a surprise that there is no unique way to define resilience. While the majority of definitions focused on the capability to cope with failures providing a reactive approach, resilience engineering focused on the ability to adjust prior to or following a failure. Resilience engineering explores ways that enhance the ability of the organizations to be robust and flexible and make the organizations prepared to cope with the unexpected. This definition focused on variability, adaptability and unpredictability

We explore resilience engineering and the premises for resilience engineering will have an influence on the understanding of the phenomena that we studied and the solutions that we identified (Hollnagel, 2007). These premises are:

- Since it is not possible to describe in detail all operations and resources are limited, performance variability is necessary
- Many adverse events could contribute to a success or to a failure. These adverse events are the result of adaptations to cope with complexity
- Safety management must be reactive and proactive. Safety management shall take into account both hindsight and the ability of the organisation (system) to make proper adjustments to anticipate potential threats, monitor risk, revise risk models and to use resources proactively.

In this context, the qualities required for a system to be resilient are illustrated in Figure 1.

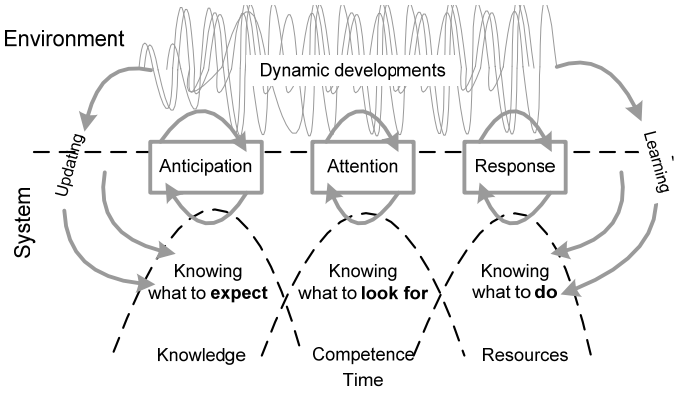

Figure 1. Required qualities of a resilient system (Hollnagel, Woods and Leveson, 2006)

These qualities are related to the ability to:

- Respond to regular and irregular threats in a robust and flexible manner. This is the reactive part of safety management. The system is designed to a limited range of responses. There is still a necessity to adjust responses in a flexible way to unexpected demands.
- Monitor in a flexible way own performance and external conditions. This monitoring focused on what it is essential to the operation. In a dynamic and unpredictable environment, it is required for the system to be able to have internal monitoring and monitor the external conditions that may affect the operation.
- Anticipate risk and opportunities. At this point it is required to go beyond risk analysis and have imagination to see what may happen and see key aspects of the future (Westrum, 1993). Is is not only of identify single events but how the may be interact and affect each other.
- Learn from experience implies from actual events not only collection of data in databases.

In resilience engineering safety is not seen as the absence of an accident but a dynamic non-event (Weick and Sutcliffe, 2001) and the capability of the system to handle unexpected situations. Resilience acknowledges that individuals and organizations must adjust to cope with current conditions. These adjustments are always approximate due to current working conditions where there is a limited amount of information, resources and time. Resilience Engineering is about to increase the ability of the organisation to make correct adjustments. The adjustments are influenced by a number of condition, these conditions are lack of time, lack of knowledge, lack of competence and lack of resources (Hollnagel and Woods, 2005). These conditions will facilitate the system to cope with the unexpected event.

Unexpected events require more time to understand the situation and decide the proper action. If unexpected events occur in several occasions, they will affect other activities and there is a possibility of loose of control. The focus in relation to time should be when time demands are real and have consequences for individuals. Knowledge is required to understand the event and “what happened” and competence is related to “knowing what to do” even if the unexpected event has gone beyond design limits. An unexpected event will require the use of resources to regain control. Finally, the experienced learned from the management of the unexpected events need to go back to the system in order to augment response capacity.

The resilience engineering concept presented in this section is adapted to the oil and gas case to analyse the ability of the organisation to anticipate, monitor, respond and learn together with the conditions that influence this ability

3 METHOD: ADAPTATION AND USE OF THE RESILIENCE MODEL

Based on the increasing number of occupational accidents, StatoilHydro initiated a project in cooperation with SINTEF. The scope was to turn the negative trend identifying safety measures dedicated to the pilot Heidrun TLP.

The action research approach that was used on Heidrun TLP is a part of an organizational development (OD) process (Greenwood & Levin 1998). The goal of this process was to increase the quality of adjustments and to improve occupational safety in the organization. In the OD process we focused on working conditions that influence the ability to make proper adjustments; sufficient time, knowledge, competence and resources (Hollnagel and Woods, 2005). In our early information gathering we saw that the psychosocial work environment on Heidrun TLP also could have a significant influence on the ability to make proper adjustments, and therefore added this as a condition.

With this background we developed a working model that was used to structure the interviews and as a starting point for the discussions in the search conference.

"Knowledge and Competence" was merged in the model due to pedagogical reasons (although the difference was explained orally) and the factor "psychosocial work environment" was added, resulting in four main factors as indicated in the Figure 2 below.

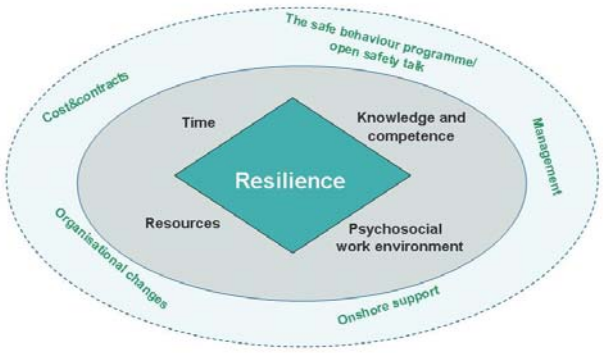

Figure 2 The adapted resilience model

Based on initial discussions with the safety staff some external factors where identified, anticipated to influence the safety level on Heidrun TLP. These external factors are; "The safe behaviour programme" (a large safety campaign), "open safety talk", "cost &contracts", "organisational changes", "onshore support" and last but not least "management".

All factors in the resilience model were discussed through approximately 40 semi-structured interviews, mostly by offshore workers. All kind of positions where covered; both internal StatoilHydro and contractor employees. The main findings were extracted from the interviews and sorted by the factors in the resilience model.

The findings from the interviews were the main input to the creative search conference, also gathering around 40 persons. The participants represented both on and off shore personnel and internal and external StatoilHydro personnel. The two day conference was arranged with a mix between plenum and group sessions to discuss and suggest safety measures. The second day of the conference was dedicated to identification of measures; i.e. how could Heidrun become a more resilient organization.

4 RESULTS

The safety measures identified in the search conference were sorted and defined as HSE activities. These were presented and prioritized in a management meeting in the Heidrun organization and the end result from the project was nine HSE activities;

- Safety conversations
- Buddy system
- Collaboration in practise
- The supervisor role
- Consistent management
- Clarification of the concept "visible management"
- Meeting/session for chiefs of operation
- Risk comprehension course
- Visualisation of events

These activities are now put into action. "Safety conversations" cover both formal and informal conversation were safety is a topic either explicit or indirectly. The aim of this measure is first of all to enhance the quality of these conversations by observing good and less good practice and applying training when necessary. In the "Buddy system" colleagues are assigned to take care of new colleagues. This HSE activity will contribute to an enhanced quality of this system by observation of practice, exchange of experience and training. In the "Collaboration in practice" activity different work groups are brought together to be more familiar with own work in relation to others work. The aim is to clarify roles and responsibilities in the common work processes and to increase knowledge about each others work.

"The supervisor role" is a role that needs to be developed and clarified as this role has changed. The supervisor is the daily manager for the work force on the installation and he has direct contact with the crew and has a thorough knowledge about the operations. This activity will aim at clarifying this role and identify need for enhanced competence. "Consistent management" will help the managers to agree on common practice on reactions to insecure behaviour.

The crew onboard the installation request more "Visible management", but at the same time the management claim that they have too little time to be visible. It is however rather diffuse what is meant by this expression and the activity will help to clarify this. "Meeting/session for the chiefs of operation" shall be an arena for good and constructive discussions about safety related topics. This activity will define topics to be addressed and will contribute in design of fruitful processes for these meetings. "Risk comprehensive course" shall develop different courses with the aim to enhance the comprehensive of risk. Finally the "Visualisation of events" activity will follow up and extend visualisation of events through animations and video and will also encourage the use of drawings in reporting of events.

5 DISCUSSION

Three main qualities are required for a resilient organization. These are anticipation, attention and response. These qualities are described in a theoretical way in the theory section but as an introduction to the discussion we will give a practical example related to occupation accidents.

If a group of people onboard an oil installation shall install a heavy valve together, they need to be well coordinated. They need knowledge about how to carry out the operation including who is responsible for what. Competences on the risky situations they go through in this operation are also essential. This knowledge represents "anticipation", knowing what to expect. When the operation proceeds they also need to have competence on how to interpret the situation and what to look for to be aware of the risky situation, "attention" is needed. When a risky situation is observed it is crucial that they "respond" to it and respond in a correct way. It is not unusual that an employee do not respond if he sees that an employee in a higher position do not follow safety procedures. Trust is essential to secure response. Time and resources is also important to avoid that critical situation are not responded to because they like to "get the job done" in due time.

How can the identified HSE activities potentially influence attention, anticipation and response? The following table shows how we interpret this.

Table 1. Activities influencing anticipation, attention and response

	Anticipation	Attention	Response
Safety conversation	x	x	(x)
Buddy system	x	(x)	(x)
Collaboration in practice	x		
The supervisor role	x	(x)	(x)
Consistent management	x	(x)	
Clarification of "visible management"		(x)	
Session for chiefs of operation	x		
Risk perception course	(x)	(x)	
Visualization	(x)	(x)	

The activity "Safety conversation" covers all conversations where safety is an issue and the purpose is to enhance the quality of these conversations. When safety issues are treated in a proper way they will increase the knowledge about safety, and clarify *anticipations* and what to expect. Safety conversations can also influence *attention*, e.g. what to look for in terms of hazards in their daily work. One purpose of safety conversations between employees and managers is also to increase the awareness of how to *respond* to critical situations.

The "Buddy system" will in itself contribute to make newcomers to the installation more familiar and increase the competence both about the installation and how work is performed. Increasing the quality of this system and giving the "buddies" support so that they can be more prepared for this role may improve the newcomer`s *anticipation, attention and response*.

"Collaboration in practice" will especially give a better clarification of what to expect (*anticipation*) regarding how the work that is carried out in a safe manner.

The supervisors are close to the daily operations. By increasing their knowledge and skills, this may have an important effect on anticipation. Indirectly and dependent on the skills the supervisors acquire, both *attention* and the quality of *response* may increase.

The goal of the activity "Consistent management" is to give managers a common understanding of how to respond to safe and non- safe behavior. Consistent positive and negative feedback that is regarded fair can potentially increase both *anticipation* and *attention*. Response regarded as unfair can worsen the psychosocial working environment and thereby decreasing the two qualities.

A management that is visible to the employees in terms of safety issues can in itself have a positive effect on *attention.* The activity "Clarification of "visible management" will in the first stage only define the meaning of the term and will thereby not

contribute to resilience before something is done to make the managers more visible.

Introducing safety issues in meetings for chiefs of operations in a positive way can increase the managers knowledge about safety - *anticipation*.

Both ”risk comprehension course” and ”Visualization of events” can increase knowledge about safety (*anticipation*) and also competence on how to be aware of the risky situations (*attention*), but this effect is dependent on a high quality and a proper use.

We see that most of the activities can potentially improve the anticipation of risk and opportunities. More uncertain are the influences on appropriate responses to threats and also on attention; the monitoring of performance and conditions. Attention and response are the two qualities that are most difficult to change or improve. Both attention and response can be regarded as behavior. Thus a change in these two qualities require a behavioral change. Anticipation can be regarded as a cognitive process, and is as such easier to change than behavior. Still, behavior change is crucial in the building of resilience. How the nine activities actually contribute to behavior change is still an open question, as the effects have not yet been evaluated.

6 CONCLUSION

The research question for this paper was how resilience can be built in practice in organizations. We have illustrated that the use of an action research approach, using search conferences potentially could have a positive influence on qualities that are required for resilient organizations; anticipation, attention and response. Our focus has been occupational injuries, but the approach could be valid for safety work in general.

The approach and process used in the case study demonstrates that a proactive approach to safety issues is motivating for the personnel involved. Statistics and reports on accidents are widely used to improve safety. Some fatigue can be observed among the personnel related to safety work using this approach. The feedback from this project was that the personnel had no difficulties dealing with the resilience concept as it was used in the project. Resilience was a construct that the offshore personnel liked to be associated with. One of the participants in the search conference, a safety delegate, expressed that this was the most interesting HSE meeting he had participated in during the last 25 years. The terms from the resilience model have been adapted and used during daily safety work on the installation. We may conclude that it is more motivating to use the proactive approach in practical safety improvement work.

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