Risk control in complex environments

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Building safety by resilient organization – A case specific approach

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ABSTRACT: The paper presents key findings from the research project "Building Safety". Building Safety aims to generate knowledge for building *resilient* operational organizations for petroleum production in the northern regions. The results of the study should serve as input for Eni Norge, in their current preparation for petroleum production at the Goliat field in the Barents Sea. The paper presents how resilience was operationalized and empirically tested in a case study of successful recovery of incidents. Based on theoretical contributions on resilience and Resilience Engineering (RE), the following 'Contributing Success Factors' (CSFs) were operationalized and examined: CSF1 Risk Awareness, CSF2 Response Capacity, and CSF3 Support. The paper concludes with case specific advice for building a resilient organization: (1) apply scenario analyses, (2) prepare for successful improvisation, (3) assess IO (Integrated Operations) effects on resilience attributes, (4) ensure awareness of ongoing work processes at all levels, and (5) share risks and objectives.

1 INTRODUCTION

Oil and gas exploration in the Northern Regions is a controversial topic in Norway. Authority approval of activity in these regions is based on strict demands. In fact, a zero tolerance regime for oil spills has been introduced. This paper presents key findings from "Building Safety", a research project aiming to generate knowledge to build *resilient* operational organizations for petroleum production in the northern regions. Ideas revolving around the concept of resilience are currently met with interest within safety science and management. In psychological terms, 'resilience' refers to the capacity of an individual to both endure and "bounce back from" strain. A similar description is applied to describe resilient organizations. A resilient organization is a system that possesses the ability to endure and recover from severe strain. Hollnagel (2006) describes resilience as "the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress". Ideally, the resilient organization is able to both endure and successfully recover from severe strain.

The aim of the current paper is to report how the concept of 'resilience' was operationalized and empirically tested in a case study of successful recovery of high-risk incidents. The paper concludes by presenting a set of recommendations for building a resilient organization.

Although the research activities in Building Safety have pursued generic knowledge, it has been equally important that the results could serve as case specific input for Eni Norge, in their current preparation for petroleum production at the Goliat field in the Barents Sea.

Goliat is located in the southern part of the Barents Sea in a sub-arctic climate. This will be the first oil development in the Barents Sea. The field will be developed with Subsea installations tied back to a circular Floating Production Storage and Offloading (FPSO) facility. The Goliat field development and operation is subject to strict environmental requirements according to the Integrated Management Plan for the Barents Sea, issued by the Norwegian Parliament.

The scope in Building Safety has been to examine organizational and human contribution to resilience, with the petroleum production in the Northern regions of Norway as background case. In order to specify the context for examining contributors for resilience, focus was directed towards incidents and near-misses. As emphasized by Hale (1997), incidents and near-misses are typically met with a set of responses similar to those of accidents; although in a less traumatic form: (1) the hunt for scapegoats, (2) the wish to understand what happened, and (3) the wish to learn from what happened as it must never happen again. However, Hale points out that for incidents and near-misses, there is often an additional fourth response: (4) the feeling of relief that nothing worse occurred, trying to forget it fast, and moving on. If this last response is dominating, then the possibilities of lessons learned are lost. Recognizing the importance of avoiding this fourth response as a step towards building organizational endurance and recovery capacity (i.e. resilience); a specific objective within Building Safety was to examine processes of incidents that were successfully recovered.

A case study was performed, aiming to explore how an operationalized set of factors (based on resilience) contributed to recovery or prevention of incidents.

2 SUCCESSFUL RECOVERY OF HIGH-RISK INCIDENTS

The first step towards studying resilience in the context of recovery was to operationalize resilience. A set of resilience based "Contributing Success Factors" (CSFs) was defined and hypothesized as possible contributors. These CSFs were identified on the basis of literature reviews (Grøtan *et al*., 2008a) and a theoretical study on resilience and improvisation (Grøtan *et al*., 2008b). The CSFs were then used for a case study of high-risk incidents that were successfully recovered.

2.1 *Resilience operationalized*

Underestimation of risks is a significant contributor in drifts towards failure. By implication, this suggests that sustained risk awareness is of key importance for a resilient organization. The dynamics related to adaptation is an important element in resilience. Adaptation (as a capacity to adjust and adapt), is comprised of knowledge in terms of Anticipation (what to expect), Attention (what to look for), and Response (what to do). It is important to emphasize that these elements (A-A-R) are not thought of as a sequence, i.e. such that anticipation precedes attention, which in turn precedes response. Instead, all three factors are continuously active. This steady state of alertness is made possible by constant updating of knowledge, competence, and resources (Hollnagel and Woods, 2006). Based on the above, the following variables were hypothesized as potential contributors for successful recovery: *Risk understanding; Anticipation; Attention; Response*.

In addition to being dynamic and ongoing, the process of adaptation (A-A-R) suggests the possibility of managing exceptions beyond day to day routine operation. This capacity ties in with the need to be flexible in order to cope with change and the unexpected. Adaptation (A-A-R) denotes being ready for the next surprise. As this preparedness represents a way to meet what is beyond routine, the handling (response) may well also be outside of standard practice. In other words, the process of adaptation includes aspects of improvisation. The capacity to improvise may be mandatory to complement and compensate for insufficient automatic security systems and unsuitable or lacking procedures (Cunha, Cunha, and Kamoche, 2002; Mendonça, Beroggi, and Wallace, 2003; Mendonça and Fiedrich, 2006). Mendonça and Fiedrich (2006) define improvisation as "a combined behavioural and cognitive activity that requires serial creativity under tight time constraint in order to meet performance objectives." The adaptation process in the RE framework suggests a level of creativity that enables the agent to foresee, be aware of, and handle the unexpected. The emphasis on thinking, interpretation, and action (response) as tightly tied activities is close to Cunha *et al*.'s description of improvisation as "thinking in action" (Cunha *et al*., 2002). This element of creativity is reminiscent of the capacity to improvise (for a more detailed discussion regarding the element of improvisation in resilience, see Grøtan *et al*., 2009; Størseth, *et al*. 2009). Based on the above reasoning, it was assumed that *improvisational aspects* are embedded in the resilience adaptation process of A-A-R (Hollnagel and Woods, 2006).

For an organization to be resilient there must be a practice of decision support, e.g. related to the production/safety trade-offs. That is, there must be guidance for when to reduce or stop production in order to reduce risk. These kinds of "sacrifice judgements" (i.e. when production demands are sacrificed to maintain necessary safety standards) must be supported (Woods and Wreathall, 2003). Decision support was thus hypothesized as a contributor for successful recovery.

Tierney (2003) defines resilience as "the capacity for both physical and social systems to withstand forces and demands generated by disaster events (e.g., earthquakes, hurricanes, human induced events) and to adequately cope with such events through employing effective response and recovery strategies". Both physical and social aspects of resilience can be further specified as being comprised of *robustness* (ability to withstand stress/demands without suffering damage, degradation or loss of function); *redundancy* (the extent to which elements, systems, and other units of analysis exist that meet functional requirements in the face of disruption, degradation, or loss of functionality); *resourcefulness* (capacity to identify problems, establish priorities and mobilize resources to avoid or cope with damage or disturbance); *rapidity* (capacity to meet priorities and achieving goals in time).

Accordingly, these variables were hypothesized as recovery contributors: *Robustness; Redundancy; Resourcefulness/rapidity* (as both resourcefulness and rapidity refers to the ability to prioritize they were merged into one hypothesized variable).

The variables as presented above where then categorized into a hypothesized factor structure. Based on the meaning of each variable, they were classified into a structure of three Contributing Success Factors (CSFs) for recovery and prevention of incidents. See Table 1.

This set of resilience based factors formed the starting point for the approach to study high-risk incidents.

2.2 *Study of high-risk incidents*

It is beyond the scope of this paper to go into detail on each incident, and to report the full discussion of the results. The focus is rather on presenting the approach that was applied in order to explore how the CSFs contributed in the process of successful recovery.

2.2.1 *Study design*

Two pilot interviews were performed as a preliminary test of the feasibility of obtaining detailed information on specific incidents. The results of these pilot interviews served as input for the interview guide and overall study design for the main study of high-risk incidents. The main study was designed as a three-part research interview: The first part of the interview had

Table 1. Contributing success factors (CSFs).

CSF1 Risk Awareness
Risk understanding (CSF1.1): Knowledge/competence to identify something as a risk. Risk understanding is thus the composite of experience and knowledge that risk perceptions are based upon.
Anticipation* (CSF1.2): Knowledge in terms of what to expect.
Attention* (CSF1.3): Knowledge in terms of what to look for.
CSF2 Response capacity
Response* (CSF2.1): Knowing what to do.
Robustness (CSF2.2): Ability to withstand stress/demands without suffering damage, degradation or loss of function.
Resourcefulness/rapidity (CSF2.3): Capacity to identify problems, establish and meet priorities, mobilize resources to avoid or cope with damage or disturbance; and achieving goals in time.
CSF3 Support
Decision support (CSF3.1): For an organization to be resilient there must be a practice of decision support; e.g. related to production/safety trade-offs, this involves guidance for when to reduce or stop production in order to reduce risk. These kinds of "sacrifice judgments" (when production demands are sacrificed to maintain necessary safety standards) must be supported (Woods, 2006).
Redundancy (CSF3.2): The extents to which elements, systems, and other units of analysis exist that meet functional requirements in the face of disruption, degradation, or loss of functionality. Human resources and organizational redundancy falls into this category.

* = Elements in the adaptation process in Resilience Engineering (Hollnagel and Woods, 2006).

an open and unstructured form. The purpose was to gain an understanding of the interviewee's history, experience, and role(s) within the industry; and discuss high-risk incidents that were recovered successfully. The second part of the interview involved pursuing one specific incident in more detail. The key point in this part of the interview was to map the incident in a STEP-diagram in collaboration with the interviewee. 'STEP' refers to Sequentially Timed Events Plotting (Hendrick and Benner, 1987).

It should be noted that a complete STEP-analysis was not performed. The methodology was applied as a support tool for establishing a sufficient understanding of the incident at hand. Also, by developing the model in collaboration with the interviewee, we were able to attain an immediate quality control of our understanding of the incident. In the third and final part of the interview, the interviewees were asked a set of structured questions, based on the CSF operationalization of resilience.

The interviews were administrated by two researchers. A doctorate candidate was present with observatory status. Six interviews were executed over a two day period. The interviews lasted approximately 2 hours each.

2.2.2 *Participants*

Six interview candidates were selected based on recommendation. The candidates were contacted and invited to participate by the oil and gas company that had recommended them. In the invitation, the candidates were asked to prepare for the interview by thinking through/recollecting experiences involving incidents with successful recovery. All candidates accepted the invitation and agreed to participate in the interviews. The participants were all male, each with relevant background from the petroleum industry, ranging from the late 1960s up until today. Their experiences covered a wide range of the petroleum industry, from offshore operational work to onshore top management.

2.2.3 *Key results*

The results that are commented on here are based on the analyses of three of the six interviews.

Although each case had their unique path of scenario development, the dynamics that took place in the incident development share interesting common features: Elements of Risk Awareness (CSF1) and Support (CSF3) were in some way missing in all three cases. Specifically, this involved Risk understanding (CSF1.1), Anticipation (CSF1.2) and Redundancy (CSF3.2). If these contributing factors for successful recovery had been present, the incidents may potentially have been recovered at an earlier stage. The lack of redundancy in the scenarios involved similarities along the lines of:

- Information and participation in decision processes were not open to involved parties.
- The need for communication was not recognized (e.g. the need to provide a total picture of the ongoing activities involving risks was not realized).
- Culturally based lack of willingness to share information was eminent.

Consequently, it is plausible to argue that Risk Awareness (CSF1) could have been triggered earlier (possibly leading to adequate action), if redundancy (3.2, in CSF3 Support) had been sufficiently accounted for.

More generally, the lack of Risk Awareness and Support in these cases emphasizes the importance of paying attention to links between organizational level features and operational/individual level action/performance. The CSFs as operationalized and examined here appear promising as a way to systematically look into dynamics of this character.

3 CASE SPECIFIC ADVICE

The following is a set of case specific advice for the establishment of the operational organization of the Goliat field. The recommendations are derived from the main results from the research activities in Building Safety regarding human and organizational contribution to resilience. The recommendations are focused on four conceptual themes, based on manning strategy: (1) training and development, (2) integrated operations (IO), (3) work teams, and (4) external resources.

3.1 *Training and development*

Approaches as applied in the HSE (Health, Safety, Environment) Awareness programme could be used to introduce new personnel to the Eni emphasis on risk awareness. SINTEF assists Eni Norge in their development/implementation of a HSE Awareness programme, targeted towards different groups within Eni Norge and collaborators. The HSE Awareness programme works to develop and implement a common awareness, way to think; a common Eni mindset concerning HSE.

Specifically, the HSE Awareness concept "Share and Win" can be incorporated into recruiting and training processes. In 2007, Eni Norge and SINTEF (in the HSE Awareness programme) held a workshop on the handling of critical decisions involving conflicts and trade-offs between safety and competing goals. Based on the values of sharing knowledge, experiences, and disagreement – the workshop was entitled "Share and Win". "Share and Win" refers both to the values of sharing knowledge etc., but also to the concept/methodological approach in this workshop. The "Share and Win"-concept is currently assessed for further development and application in the HSE Awareness programme.

Recommendation # 1 – Apply scenario analyses:
Engage in scenario analyses on real cases of incidents/near-misses with an established focus on the values of cooperation, communication, and learning/sharing knowledge.

- The purpose would be to become aware of how Risk Awareness, Response Capacity, and Support (i.e. the three CSFs) are linked and dependent upon each other in their contribution for successful recovery of incidents.
- This kind of scenario analysis should be targeted towards improving the ability to anticipate and pay attention to patterns of system behaviour.
- The scenarios should be specific, detailed, and imply that the boundaries for acceptable performance become visible.

Recommendation # 2 – Prepare for successful improvisation:
Prepare for improvisation, as this is needed in situations where unforeseen events occur.

- To respond adequately in a situation involving improvisation, personnel should have available, and efficiently master a set of response options that allows flexible intervention, depending on the particular needs in the situation at hand.
- For successful improvisation it would also be of importance that the operators obtain feedback (as immediately as possible) on the effects of their responses, to allow them to adjust their course of action.
- Improvisation is needed in situations where unforeseen events occur. By the consequence of being unforeseen, it falls outside of the organizational design. The ability of an organization to reconfigure spontaneously in demanding operating situations is a key characteristic of high-reliability organization (e.g. LaPorte and Consolini, 1991). This suggests that "improvising organizations" should allow for reconfiguration of their work organization when required.

3.2 *Integrated Operations*

IO creates new tight operational collaboration and substantial changes in work patterns offshore and in onshore support services. Eni Norge is currently developing a specific strategy regarding IO, for the Goliat field. An assessment of the safety effect of changes in work patterns and collaboration is desirable, but also challenging. One contribution to such an assessment would be an evaluation of the foreseen positive and/or negative effects on the attributes of resilience as expressed through the CSFs (see Table 1). The CSFs may in this way be used as a form of anticipatory scenario analysis.

Recommendation # 3 – Assess IO effects on resilience attributes:
Use the CSFs as specific themes to look at how IO potentially contributes to strengthen or represents a threat to a resilient organization.

- Use the CSFs as themes to analyze the potential for *situational awareness* (understanding the situation, overview of the circumstances and allocation of resources at the 1st line of emergency) during a crisis.
- In a crisis handling, interactions between actors change and new people may be brought in for support. Use the CSFs as themes to analyze the *transition from normal operation to crisis*.
- During a crisis handling, opinions may differ and informal *roles and power issues* may come into play. Use the CSF themes to look at potential group mechanisms in the IO setting.

For more information regarding situational awareness, transition from normal operation to crisis, and roles and power issues, see Skjerve, Albrechtsen, and Tveiten, 2008. *Note:* The CSFs may also be applied in an IO training context; in terms of specifying themes (Risk Awareness, Response Capacity, and Support) that illustrates the interdependencies between onshore – offshore.

3.3 *Work teams*

The incidents in the three cases referred to ended all with successful recovery. As the incidents were recovered, it is easy to move on without questions. Conversely however, one might ask how the development of such scenarios could have been prevented in the first place. Herein lays the rationale for the CSFs. A common finding that can be derived from the cases is the importance of knowing/understanding how risks emerge in interaction. These findings may be used in order to understand work team dynamics. Specifically, the findings demonstrate the need to bring awareness to the "total picture" of the work process.

Recommendation # 4 – Ensure awareness of ongoing work processes at all levels:
Ensure that personnel becomes aware of the "total picture" of the work process, i.e. awareness of "the others", awareness of the fact that the sum of a complex set of work processes creates a complex set of risk possibilities.

Redundancy (CSF3.2) is an important issue here, in terms of designing for necessary buffer capacity. This buffer capacity concerns several levels:

- Ensure that knowledge is spread out to the individuals in the work teams.
- Ensure that the work teams have a knowledge level that is sufficiently robust.
- Ensure that the "total picture" is present in the onshore – offshore cooperation.
- Ensure that knowledge is shared across organizational borders (e.g. collaboration between work teams from different organizations).

3.4 *External resources*

A strategy for the use of external resources is that contracts should be based on sharing risk and reward in achieving common objectives. This will promote collaboration across organizational borders, aiming at a unified operational organization. This operational organization is to some extent "virtual" since some of the external resources may be located far from the production site.

The question is therefore how to introduce and communicate the "Eni Way" to the external resources. Recommendation # 4 (see above) is relevant here; i.e. the value of becoming aware of the "total picture", beyond ones own isolated work task. The CSFs may be used as guideline topics when this is communicated.

Additionally, the "Share and Win"-concept (i.e. the value of sharing knowledge/experiences) from the HSE Awareness programme may be used to ensure successful incorporation of external resources.

Recommendation # 5 – Share risks and objectives:
Ensure that external resources shares risks and objectives by:

- Introducing external resources to the "total picture" (see recommendation # 4).
- Use of the "Share and Win"-concept to communicate and exemplify the values of sharing knowledge and experiences.
- Giving access to data/information regarding new work processes related to integrated operations (Øien and Schjølberg (2008) found that entrepreneurs experience lack of data access as a problem; and that they would like a closer collaboration and be more involved).

4 CONCLUSION

The contributing factors for successful recovery appear as a promising approach for studying incidents that has happened (post hoc analysis), but also as part of proactive efforts to expose implicated risk hubs in new scenarios, e.g. consequences of new technology and new ways of organizing work.

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