Reliability, Risk and Safety: Theory and Applications – Briš, Guedes Soares & Martorell (eds)

Exploring safety critical decision-making

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ABSTRACT: Inadequate handling of conflicting goals has repeatedly been identified as a causal or contributing factor in accidents. This paper documents a workshop approach designed to allow participants to explore the boundaries towards unacceptable risk and the forces driving actors towards that boundary. Participants with diverse professional backgrounds discussed a specific, actual event involving a trade-off between a certain economic loss and the risk of a much larger loss. The discussions revealed that none of the participants had entered the workshop with a comprehensive understanding of all aspects of the incident. The participants expressed being surprised by: the comprehensive list of possible outcomes, decision options, events that were identified during the discussions, and the difficulties encountered when trying to formulate a specific criteria. The results emphasize the value of discussions on specific incidents / scenarios in order to bring the boundaries of unacceptable risk to the fore.

1 INTRODUCTION

People at all organizational levels face critical decisions involving conflicts or tradeoffs between safety and competing goals such as staying within budgets, completing projects on schedule, avoiding downtime or simply getting their job done. Inadequate handling of conflicting goals has repeatedly been identified as a causal or contributing factor in accidents. Commonly used strategies for ensuring safe handling of goal conflicts are attempts to influence attitudes through campaigns, slogans etc. (or attempts to influence behaviour through incentive systems which may include negative sanctions for decisions deemed inadequate) (Swuste et al., 2008; Ryggvik, 2008). Based on a study of 57 accidents at sea, Wagenaar and Groeneweg (1987) concluded that very few accidents are the consequence of deliberate risk taking by persons at the sharp end, i.e. close to the sources of danger. A large majority of the captains had been completely taken by surprise. They had been running a risk rather than taking a risk.

Jens Rasmussen (1994, 1997) argued that behaviour is likely to migrate towards the boundary of acceptable risk as a combined effect of management pressure towards efficiency and a gradient towards least effort. The exact boundary towards unacceptable risk is not always salient to the actors, in particular in complex systems where different actors attempt to optimize their own performance without complete knowledge about how their decisions may interact with decisions made by other actors. Rasmussen therefore argues that efforts to improve safety-critical decision-making should focus on making the boundaries towards unacceptable risk explicit and known. Traditional strategies for ensuring safe handling of conflicting goals rarely meet these objectives.

The aim of this paper is to document a workshop approach designed to allow participants to explore the boundaries towards unacceptable risk as well as the pressures driving actors towards that boundary. We hypothesised that

1. A group with diverse backgrounds would be able to build a more comprehensive understanding of the event than any single individual.
2. The participants would not be likely to consider the whole range of possible outcomes of each decision option unless they were asked to list those consequences.
3. A group with diverse backgrounds would be necessary to formulate and justify precise criteria for handling the critical decision.
4. The group process would be likely to produce commitment and mutual expectations and thus facilitate the implementation of follow-up actions.
5. It would be necessary to create a non-threatening group climate and invite divergent opinions in order to achieve the potential of a group approach.

2 METHOD

2.1 *Case selection and description*

In preparation for the workshop, the company was engaged to find a suitable case that answered to the following criteria: That the case involved elements of

(1) safety critical decision-making, (2) the potential of conflicting objectives / "trade-offs". The following incident was selected as the case for the workshop:

2.2 *Case description: Disconnection of riser during peak storm*

The incident occurred on a offshore drilling rig operating on the Norwegian continental shelf. The riser is a vertical tube connecting the well at the sea bottom with the rig. The riser contains the drill string as well as drilling mud, which is used to transport well cuttings from the bottom of the well and to control the pressure in the well. The Bridge Document of the rig included a criterion saying that the riser should be disconnected if the wave height surpasses 6 meters. This criterion was based on analysis of the mooring arrangement of the rig at that specific location, and it was stricter than the disconnection criterion applying to that rig at other locations.

Riser disconnection requires several preparatory actions to strengthen barriers against breakage of the riser and blow-out. In dialogue with onshore personnel (drilling operation leader and Health, Safety, Environment and Quality (HSEQ) staff), suitable weight within the well must be settled and the drill string and drilling mud in the riser must be replaced by brine. Further, the riser must be filled and the drill string must be pulled to close the BOP (Blow Out Preventor). These preparations take several hours, whereas a prepared disconnection only takes a few minutes to perform. Reconnection after a disconnection takes several days. The economic loss associated with downtime after disconnection is shared between the rig owner and the operating company hiring the rig, as the rig will go at a reduced rate for as long as the drilling activities are suspended.

The formal decision about riser disconnection is made by the rig manager. The rig manager receives information from the stability leader; the stability leader is also second leader and maritime safety-leader on the rig. In addition, the on board drilling supervisor (from the operator company) knows, and is expected to act in accordance with these criteria.

At the time of the incident, the rig was in an early phase of drilling a deep sea well. The well had not yet reached hydrocarbons under pressure, so blowout risk was not an issue. The weather forecast for the day of the incident announced a peak storm, i.e. a storm characterized by a rapid increase and decrease. Based on the wave height criteria for disconnection, the rig manager planned and prepared for disconnecting the riser. Preparations for disconnection involved stopping work and filling the riser with water. The platform manager discussed and planned for disconnection with onshore personnel including HSEQ staff. As the storm developed, the offshore staff monitored the peak storm development very closely. They registered two heaves that exceeded the eight meter disconnection criterion before the waves subsided Due to the expectation that the strong part of the storm would last for a very short time, the rig manager concluded that the equipment would be strong enough to handle the situation, and he decided not to disconnect.

2.3 *Participants*

The workshop participants were selected by the company that had experienced the incident; and were selected based on both their knowledge and direct experience with the given incident, and / or their knowledge and position in general. The participants (N=15), had diverse roles and backgrounds: including operational work offshore, to more administrative, managerial onshore positions, and HSEQ staff. All participants were familiar with some aspects of the case before the workshop. However, we expected their knowledge to be complementary to a significant extent, so that they would have to share knowledge in order to build a comprehensive understanding of the event.

2.4 *The workshop design*

Based on our set of hypotheses (as presented in the introduction), the workshop was designed in collaboration with the company at which the riser incident had occurred. The workshop was designed to share insights concerning safety-critical decision-making by in depth exploration of one incident: Riser disconnection during a peak storm.

The workshop consisted of three main parts: (1) introduction, (2) scenario analysis, and (3) group discussion. In the *introduction*, the fundamental hypothesis of the study was presented explicitly to the participants, i.e. that the joint effort of participants from diverse backgrounds would generate a more comprehensive understanding of the contributory processes that in sum had produced the incident. The workshop was titled "Share and Win" in order to emphasise this idea. Emphasis was put on the fact that there was no intention of identifying scapegoats, and that the aim was not to reach consensus. Rather, the value of disagreement was explicitly emphasized, and the groups were urged to record the divergent points of view that might occur during the discussions.

The capsizing of "The Herald of Free Enterprise" was introduced, and discussed in relation to the process of migration towards the boundary to unacceptable risk (Rasmussen, 1997). To further "tune in" the group discussion, the following question was asked: How can we improve the context for future decisions?

After having set the stage of the workshop, an overview of the case and the decision criteria for riser disconnection were presented. This was followed by a presentation of the STEP-analysis, i.e. Sequentially Timed Events Plotting (Hendrick and Benner, 1987) as a method to analyse scenarios. STEP-analysis is an accident investigation method involving a detailed mapping out of a scenario (accident) by plotting the

Table 1. Discussion topics used at the workshop.

Possible outcomes and consequences
Consider the following scenarios: 1. The rig disconnects 2. The rig does not disconnect, no physical damage is incurred 3. The rig does not disconnect. The riser is torn off • Summarise the likely main consequences for the operator and for the rig owner. (You decide what consequences are important and worth mentioning).
Decision points: • What are the critical decision points for handling a situation when it may be necessary to disconnect the riser due to bad weather? • If you want to avoid exceeding the maximum heave criterion, when do you have to act? • Who was involved at each decision point? • Who should be involved at each decision point?
Group work: Looking ahead: • Suggest 3 improvements for handling future critical decisions.

sequence of events / activities in a diagram. In the *scenario analysis* part of the workshop, the participants were divided into two groups. The objective was to discuss, and map out the incident in a STEP diagram, i.e. to identify key actors and plot the events along the timeline. Each of the group discussions/scenario analyses was followed by a research scientist.

The *group discussions* comprised the following issues: (1) the possible outcomes and consequences associated with the incident, (2) the critical decision points related to the disconnection of a riser during a storm, and (3) possible improvements for handling future critical decisions. The discussion topics are shown in Table 1. Additional discussion issues concerning authorities and responsibilities and factors influencing the decision process had been prepared, but were skipped in order to give the groups enough time to explore the first three discussion issues in depth.

The workshop was set up as two half days (lunch to lunch), and took place in a hotel conference room. Three scientific researchers were involved in the workshop facilitation. The researchers had primarily observatory status, but intervened in questions of methodological character (regarding STEP).

3 RESULTS

3.1 *Construction of STEP diagrams*

Both groups created STEP diagrams that gave a coherent account of the incident from the time of the weather forecast until the heaves declined. The diagram created by Group 1 is shown in Appendix 1. The two diagrams were similar in complexity and content. The process of creating the STEP diagrams led to extensive sharing of knowledge among group members. In particular, personnel with operative experience contributed with details concerning how the situation could be handled in practice, whereas HSEQ personnel shared their knowledge about the background for the location-specific disconnection criterion of the rig.

3.2 *Discussions of possible outcomes and consequences related to the riser case*

Both groups devised comprehensive lists of the possible consequences of the following scenarios: (1) The rig disconnects; (2) The rig does not disconnect, no physical damage is incurred; and (3) The rig does not disconnect, and the riser is torn off.

The results are shown in Tables 2, 3, and 4 respectively.

During the plenary discussion of this issue, several participants said that they were surprised to see how many and how serious consequences were associated with the different scenarios. This applied in particular to the scenario that the rig does not disconnect and the riser is torn off, but also to the scenario which actually occurred, i.e. when the riser is not disconnected and the riser is not torn off.

Table 2. Scenario: The rig disconnects.

Group 1
The rig goes to reduced rate
1-5 weeks lost time and financial impact
Potential risk to the well
Possible damage to well head during reconnection
Loss of credibility among the licensees
Group 2
Deferred duration of well and increased cost
Adhere to predefined requirements
Rig Owner may get more time to maintain rig at 90 % of operating rate!
Negative reputation for Rig Owner (poor rig per formance)

Table 3. Scenario: The rig does not disconnect, no physical damage is incurred.

Group 1
PSA will find out
Drilling contractors and drilling operations lose respect for procedures
Group 2
PSA may find out breech of operations requirements
Predefined requirements can be overridden – no value?
Money saved
Less rig motion, better sleep
Negative experience, a learning

Table 4. Scenario: The rig does not disconnect. The riser is torn off.

Group 1
Injured personnel
Possible blowout
Loss of well
Damage to BOP
Damage to rig
Stop drilling programme
Subsea salvage operation
Pollution
Loss of credibility
No new licenses
Legal prosecution
Mandatory orders
Major financial implications
Group 2
The company only: 600 mill NOK (ex. Insurance)
Loss of reputation vs. regulatory authorities and public – less licence rewards
Potential for hurting and killing people (post traumatic stress)
Equipment damage
Deferred revenue
High stress level within org.
Focus and potential overkill for next operations – more stringent practice of regulations
The company alone: Increased insurance premium

3.3 *Criteria for disconnection*

In Table 5 the groups list aspects related to the criteria for disconnection. The participants attempted to take the involved decision makers' point of view, and used the scenario analysis (STEP) as guidance. The decision criteria as presented in Table 5 reflect the proposals as they emerged during the discussions. No criticality rating was performed.

The table reveals a key point that was discussed throughout the workshop; How can the criteria be formulated so as to make it clear exactly when to push the button and initiate disconnection? Is it permissible to wait until after the first heave exceeding the disconnection criterion before pushing the button? What will happen if the rig manager is given more discretion in deciding when to disconnect?

During plenary discussions regarding the disconnection criteria, a recurrent theme was the distinction between 'criteria' and 'guideline'. Regarding this specific case, the limit for operation was set to a wave height on 6 meters. Several participants commented, however, that it is never enough to consider wave height in isolation. There are always the combination of several parameters that must be considered, e.g. control the piping, rig mooring etc.

Table 5. Criteria for disconnection.

Group 1
OIM (offshore installation manager, i.e. rig manager) decides whether to push the button on 5.9 or 6.1 m.
Push the button immediately after the first heave exceeding 6 m.
Group 2
Development of weather vs. forecast?
Rig motion characteristics on the site in the given situation vs technical equipment limits (riser angle, anchor tension, heave, thrusters, rig centre vs well centre (offset)
Disconnect when the criteria:
– Is exceeded?
– Is about to exceed?
– I think it will exceed?

3.4 *Discussion of possible improvements*

The improvements proposed by the two groups are listed in Tables 6 and 7. The proposed improvements fall into two groups: (1) measures to improve safety critical decision making in operational contexts in general, and (2) measures to improve decision specifically related to disconnection of the riser.

All proposed improvements concerned actions to support and facilitate "correct" decisions; as well as features that the company could have established before the occurrence of critical situations. There were no suggestions relating to attitude or behaviour change.

3.5 *Feedback and follow-up*

In feedback sessions during the workshop the participants noted that they had very different opinions on the issues that were discussed. They also noted that

Table 6. Measures to improve safety critical decision making in operational contexts in general.

Group 1
Ensure clear and appropriate decision support documents / tools.
The operator's procedures must be measured against the status of the rig.
Group 2
Training in decision making as organization (awareness).

Table 7. Measures to improve decision specifically related to disconnection of the riser.

Group 1
Involve and obtain subscription to operation criteria by OIM and other key people.
Make clear how the criteria are implemented.
Do not call the mandatory criteria a guideline.
Group 2
Decision makers and contributors shall?/should? be involved in defining/discussion the criteria beforehand.
Understanding of the basis for setting the ops. shut down criteria (known, understood and accepted).
Set criteria for when to initiate preparations for disconnect.

they were able to discuss a safety critical issue without clashing together.

No formal evaluation of the workshop or its effects was performed. We were informed that the follow-up actions decided at the workshop had been implemented unusually promptly, without any need for reminders. The operating company therefore challenged us to consider if particular aspects of the workshop approach could explain this prompt implementation of follow-up-actions.

4 DISCUSSION

In the Introduction to this paper we presented five hypotheses which directed the design of the workshop. The results of the workshop were compatible with these hypotheses:

In support of our *first hypothesis*, the discussions revealed that none of the participants had a comprehensive understanding of all aspects of the incident at the outset of the workshop. A comprehensive account of the accident emerged as they shared their knowledge.

Our *second hypothesis* stated that the participants were unlikely to consider the whole range of possible outcomes unless they were specifically asked to do so. We interpret the results as being compatible with this presumption, as the workshop participants were surprised to see how many and how serious consequences were associated with the different scenarios. This result is also in concordance with the finding of Wagenaar and Groeneweg (1987) that very few accidents are the consequence of deliberate risk taking by persons at the sharp end. In order to *take a risk*, a person needs to have a comprehensive knowledge about the possible outcomes and consequences related to the possible actions in a given situation. Our results suggest that it is not realistic to expect persons operating complex systems to be able to mobilize such comprehensive knowledge of outcomes and consequences when decisions have to be made rapidly.

The participants were also surprised by the difficulties they encountered when they tried to formulate specific criteria for handling the decision about disconnecting the riser. This supports our *third hypothesis*, concerning the need for diverse backgrounds to formulate and justify precise criteria for handling the critical decision.

Our *fourth hypothesis* contained the assumption that the group process would be likely to produce commitment and mutual expectations and thus facilitate the implementation of follow-up actions. This hypothesis was not formally evaluated, but we were informed that the follow-up actions decided at the workshop had been implemented unusually promptly, without any need for reminders.

The *fifth hypothesis* stated that it would be necessary to create a non-threatening group climate and invite divergent opinions in order to achieve the potential of a group approach. We deliberately selected the case and planned the workshop so as to avoid scapegoating. We also emphasised the value of disagreement and requested group members to record divergent opinions rather than strive for consensus. Paradoxically, this instruction may have been conducive to consensus, as it stimulated workshop participants to spend more effort at listening and less effort at convincing each other. We did not observe any instances of scapegoating or episodes where the discussion evaded problematic issues. In a feedback session the workshop participants noted that they were able to discuss a safety critical issue without clashing together. Moreover, the improvements suggested by the workshop participants indicated that they did not see the case as an episode of reckless behaviour. On the contrary, they focused on the need to provide decision-makers in the sharp end with the best possible aids and criteria to handle critical situations.

We used the expression "conflicting goals" several times when we introduced the topic of the workshop. Several workshop participants objected to this expression. Their rationale seemed to be that any goal conflict should be resolved in advance, e.g. through procedures, so that actors at the sharp end were relieved from making tradeoffs between safety and conflicting objectives. We believe that this is a sound principle as far as it is practicable. However, we also believe that decision-makers at the sharp end can never be entirely relieved from making tradeoffs between safety and conflicting goals. Situations not described in procedures and instructions will continue to occur, and procedures will have to leave room for discretion in order to be realistic. Therefore we maintain that the issue of handling conflicting goals should not be taken off the agenda.

The workshop was designed to speak to the collective mind of the workshop participants rather than to their hearts or stomachs. We assumed that all participants shared a commitment to safety. Accordingly, no attempt was made to mobilise emotions or to change the attitudes or values of the participants. Neither was the goal to change a specific behaviour in a specific way, since future critical decisions will have to be made under new circumstances each time. The focus was to discuss safety critical decision-making in terms of a specific case, by drawing upon the experience and expert knowledge of the participants. In other words, the workshop was propelled by the real experiences and knowledge relating to a real specific event. An important aspect here was to ensure that the integrity of the participants as professionals within their field was maintained, combined with appealing to their curiosity in terms of knowledge outside of their own field. Moreover, we wanted the workshop to demonstrate the value of sharing knowledge within the organization.

This study is limited to a single workshop. This was necessary in order to present the results in sufficient detail to discuss the hypotheses. There is clearly a need to replicate the work in order to assess the extent to which the results can be generalised.

5 CONCLUSION

We conclude that detailed discussions of specific incidents or scenarios involving conflicting goals are needed to make the boundaries towards unacceptable risk explicit and known, and to reveal the stakes involved in critical decisions. A group with diverse backgrounds proved necessary to formulate and justify precise criteria for handling the critical decision. The participants had not considered the whole range of possible outcomes of each decision option before they were asked to list those consequences.

Such discussions can lead to extensive sharing of knowledge. They can also be highly motivating for consecutive actions to control risks, provided that measures are taken to promote a non-threatening climate during the discussions. Another effect of the workshop was to enhance the awareness of the knowledge of people in other parts of the organization.

This work needs to be replicated in order to assess the extent to which the results can be generalised. There is also a need to explore to what extent such workshops lead to actual changes at the sharp end.

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APPENDIX

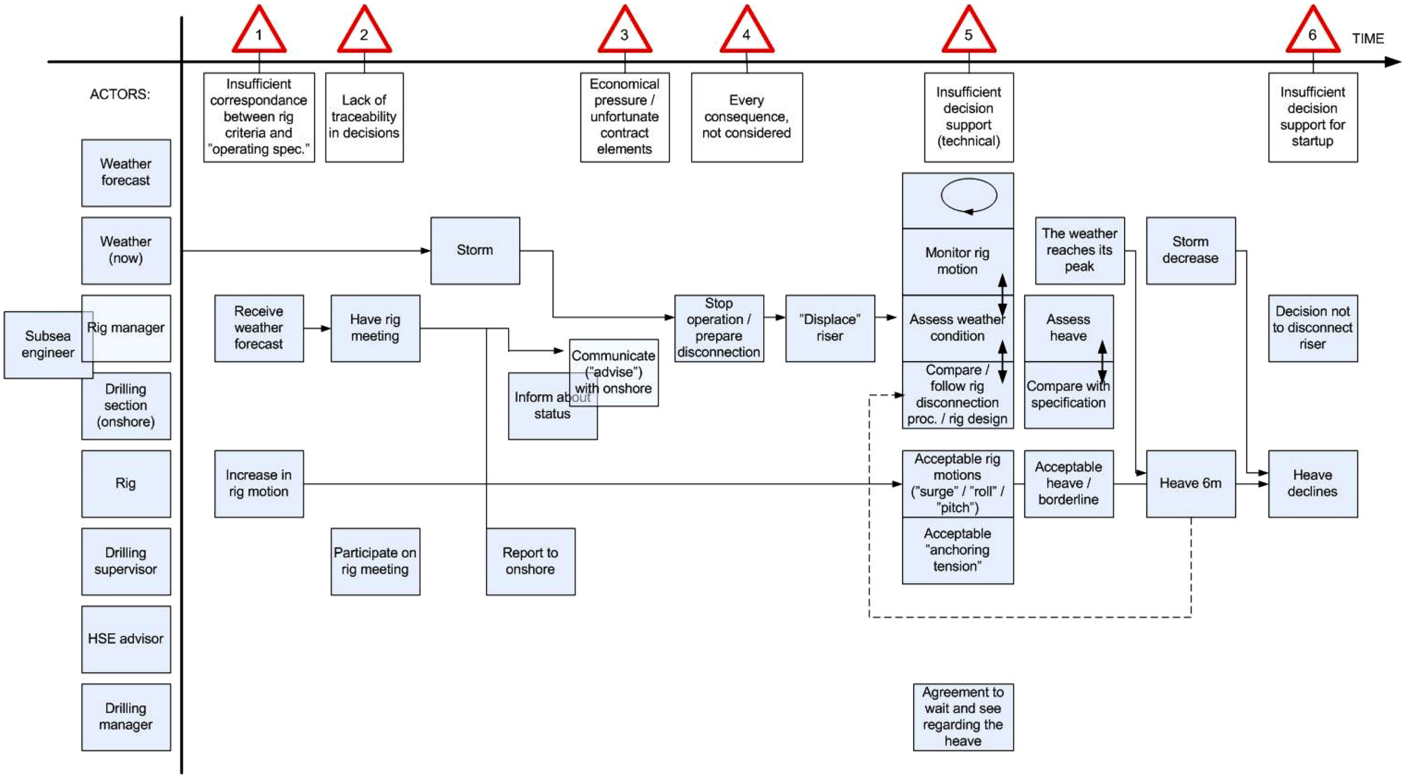

Figure 1. Scenario analysis (STEP-diagram)-group 1.