(Why) Are Cognitive human factors missing from the blunt end in the oil and gas industry?

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Abstract. The International Association of Oil & Gas producers (OGP) prioritized "*more attention paid to HF*" as one key issue after the Macondo disaster. We have explored if there is sufficient attention to HF in Norway and why HF is missing through HF verification of four control centers. Our assessment is that HF is poorly prioritized and HF experts and focus is often missing from user organizations. HF must focus on cognitive and organizational factors from the start and organizations should have competence to involve HF experts. Validation and verification from certified HF experts should be performed as early as possible.

Keywords. Safety, Human Factors, cognitive factors, organizational factors.

1. Introduction

In the last 60 years, Human factors (HF) have been developed as a research discipline. Traditionally the main domains have been physical ergonomics, cognitive factors and organizational factors, ref Karwowski (2012). HF has an important influence on work design and execution, and thus HF has a key relationship to safety. In many reviews of accidents, HF has been seen as a causal or contributing factor. The assessment of HF as a cause varies, it is suggested to be between 40 to 90 percent of accidents, depending on the industry, Rothblum et al. (2002); Luxhøj (2003); Wiegmann and Shappell (2003); DoD-Department of Defence (2005). Thus HF has been a key issue in design and operations of safety critical equipment. This has been particular evident in aviation, where HF experts has been a part of the organization and design.

The oil and gas industry is driven by new technology, and in many instances HF has been considered late, if at all. However, recent accidents have created more focus on HF. The Macondo blowout killed 11 workers, released 4.9 million barrels of oil, and generated expenditures of 42Bn$ (so far). A better design (or improved human machine interface-HMI) giving warning of a blowout may have mitigated the accident. Such a design activity is a part of the area cognitive human factors. The International Association of Oil & Gas producers (OGP), has identified "*more attention paid to HF*" as one of four prioritized areas after Macondo, ref OGP (2013), in addition OGP has prioritized Crew Resource Management training (CRM). In Norway, there has been a focus on physical ergonomics i.e. layout and work environment, based on regulation (i.e. Facilities regulation §20 – ergonomic design, and §21 HMI in PSA (2014)). Some Human factors issues are explored when designing a control center in the oil and gas industry. This has been done through the use of recognized HF standards such as ISO 11064 (2013) and alarm standards such as EEMUA-191 (2013). Cognitive factors and organisational factors are not always explored sufficiently and have been mentioned in incident investigations, PSA–RNNP (2011) and PSA (2012). A review of plans for new oil and gas fields (PUD) identified that only physical ergonomics was in focus. Several cognitive and organisational issues in the drillers workplace was identified by PSA (2007); PSA–RNNP (2011), indicating insufficient focus on HF both in design and operations. Insufficient focus on human factors has also recently been identified in the design phase during implementation of new automated technology in drilling, ref Sætren (2013). Missing focus on cognitive and organisational issues may create weaknesses and holes in defences as described by Reason (1997, 2008), and thus reduce safety and resilience.

Based on the above issues, we are exploring the questions: *Are cognitive human factors missing from the blunt end in the oil and gas industry? & Why are cognitive human factors missing from the blunt end in the oil and gas industry?* This is presented in the following sections: Method and research performed; Results and in Discussion and conclusion.

2. Method and research performed

The research questions mentioned above have initiated the following activities:

- A review of HF status in the drilling area based on relevant and recent incident reports as published by the authorities.
- A participatory review of HF in conception and design of four control centres, i.e. evaluated the focus on physical ergonomics but also cognitive factors and organizational factors. (A check of the use of CRM in 10 installations.)
- Discussion of findings in a network with Human Factors experts

We have performed a review of status in drilling based on open incident reports from the authorities and OGP, focusing on the Human Factors perspective. We have searched for reports that contain Human Factors issues in the drilling environment.

HF covers a large area during design and operations. We have focused on HF in the control centers and drillers cabin. This is a focal point of operation and safety between the technology based production process and the human operator. The reviews have been based on ISO 11064 (2013), implying a task driven iterative design process and has been conducted as a part of the verification and validation activity. The review has explored organizational issues (responsibilities, work processes, Operational philosophies..), cognitive issues (Task analysis, HMI, workload, alarm philosophies..) and physical issues (workplace layout, working environment..). The review was based on the Criop method, see Aas et al. (2009). The study has focused on the blunt end, i.e. early phases. The review of the use of HF guidelines and standards has been based on participatory action research (PAR); see Greenwood & Levin, (1998). PAR involves three basic elements: research, action and participation. PAR aims at creating a joint learning process between researchers and the various stakeholders holding interests in the problem under study, thus the findings has been discussed with the involved stakeholders, which have prioritize the findings. The reviews were conducted in workshops with experts from management, safety, work environment, automation, telecom, HF, control room users, operations and designers. The number of participants varied from 26 to 6. The workshops lasted from two to four days, with intensive reviews and discussions of HF issues.

We have also discussed the need for standards and guidelines through a Norwegian human factors network, consisting of around 400 stakeholders with expertise within HF, see www.hfc.sintef.no. A few relevant experts have been interviewed to get an impression of how HF has been prioritized in relevant projects and activities.

3. Results

In the following we have documented the results from our review and exploration.

3.1 Review of HF in drilling

In PSA(2007), the result of a survey of drillers work situation was presented. Some of the results from the drillers were: many unnecessary alarms (reported from 50% of the drillers), the alarms gives no support during upsets (reported from 20% of the drillers), no support during critical situations (reported from ca 20% of drillers) no advance indication prior to upset/problem (reported from 20% of the drillers). There was too much information on the screens (reported from 50% of drillers), a mix of old and new systems, 1/3 of drillers lose concentration and has problems keeping awake during operations and 1/3 of drillers are not aware of procedures when performing an operation.

In PSA-RNNP(2011) there was a discussion of well-control incidents, and there was a need for improved systems to present safety critical information, improved alarms and physical ergonomics such as improved layout of drillers cabin.

In the design phase, after that the systems has been selected, it is often pointed out that the driller must use systems from different vendors with different user interfaces. As an example from a review it was found that the same kind of graphs goes from top to bottom in one systems, while in another system the graphs goes from left to right. Thus there is poor coordination of HMI/cognitive factors across the different systems. This should have been addressed when the requirements for the systems were established, by specifying the need for common HMI design prior to the design phase.

In several instances the systems used in drilling had weaknesses; with inadequate designs of displays, control panels, alarm and data systems. There is also room for improvement in HMIs outside the control rooms, as an example touch screen HMIs is being used including alarm lists that cannot distinguish between alarms active unacknowledged, active acknowledged, and return to normal unacknowledged.

HF in Crane cabins can be improved, related to cognitive issues (Graphical displays; use of Closed Circuit Television - CCTV) also connected to physical ergonomics (i.e. anthropometrics/ adjustability, integrated control in the sitting chair, quality of information display and glare).

In PSA (2012), discussing an incident related to stability, it was pointed out that "Several HMI shortcomings have been identified, especially with regards to legibility and to the way information of low operational value is emphasized on the safety system's HMIs." Thus the HMI interface was not optimal, and in combination with poor training, this can make an incident more serious.

Research and development in the oil and gas area is handled by the PETROMAKS program, in the 10 year period, documented by Research Council (2012), 447 projects had been awarded grants – around 1%, i.e. 4 minor projects was related to Human Factors.

The reports and cases indicate that there are challenges related to cognitive human factors, and support the view from OGP (2013) –"more attention paid to HF", and it is suggested that HF should be more in focus in the blunt end in the early phases.

3.2 Review of HF in conception and design of four control centers

HF, to support safety and resilience, have been explored in four projects of design of control rooms (workplace design and HMI) involving remote operations and remote support. The following common issues were identified:

- Physical ergonomics: Issues related to layout and work environment were minor. The quality of voice communication between distributed actors could be improved.

- Organisational ergonomics: Responsibility, work procedures and information between distributed actors had not been explored sufficiently. New working procedures had not been explored or designed in sufficient degree. The involved participants prioritized team collaboration. Adaptions of Crew Resource Management (CRM) training were suggested.
- Cognitive ergonomics: HMI development has been immature, and should be specified more clearly, developed based on user involvement and tested in collaboration with users, suppliers and HF experts. There are many interfaces and complexity due to missing consistency between different systems from different vendors. The role of humans as a safety barrier has not been explored sufficiently. We see the need for documentation of when the human operator – with sight, hearing and perception has been a safety barrier in operations. The extensive use of CCTV in remote operations and support (i.e. more than 100 CCTVs employed) has not been based on HF guidelines. During not normally manned operations (NNM) when humans are not present - how can CCTV support the operator? What are the defined situations of hazard and danger that can be discovered on CCTV, and how can these situations or scenes be mitigated?

It was varying HF knowledge and awareness in the project teams and in the operating organisation. Only one operator had a broad set of Human factors experts integrated in their organisation. The other operators had outsourced Human Factors activities, and when discussing cognitive and organisational issues the operator used a physical ergonomics as a reference, that had scant knowledge of the area. The need for CRM training has also been explored through PAR, in 10 verification and validation projects based on ISO 11064 (2013). CRM has been conceptualized to cover areas as communication, situational awareness, teamwork, decision making, leadership and personal limitations (stress), based on a 6^{th} generation CRM concept identifying/preventing threats to safety at the earliest time and managing errors. In 6 of the 10 projects, CRM was prioritized by the participants and suggested as a prioritized issue in new control centres involving extensive collaboration between onshore and offshore. However, the CRM training has not been implemented or been in focus.

4. Discussion and conclusions

In the following we have discussed the major shortcomings, the possible causes and recommendations to improve HF. There are varying practices related to HF focus.

4.1 Major shortcomings in integrating HF in early project phases

Main issues from the review have been:

- Cognitive human and organisational factors, such as human machine interfaces, responsibilities and procedures are not prioritized in the early phases
- In drilling: poor alarm design and poor HMI, unnecessary alarms, alarms gives no support during upsets, no advance indication prior to upset, no support during critical situations, too much information on the screens, poor integration between different systems, inadequate systems, HMI not optimal, missing consistency
- Drillers are not aware of procedures, having problems keeping awake, there is poor training
- No HF guidelines used in CCTV implementation
- HF not sufficiently integrated early, and no coordination across suppliers

- Poor focus on organisational issues, i.e. documentation of organisational responsibility, poor focus on team collaboration and CRM
- Poor research funding related to HF in the oil and gas industry
- HF of voice communication between distributed actors should be improved

4.2 Possible causes to these shortcomings

It is difficult to list causes, since there is a complex relationship between societal and organizational conditions and later events, however our suggestion is:

- Too much focus on technology vs HF issues and Poor focus on HF in research prioritization
- Poor definition of organizational philosophies and responsibilities, poor task analysis, poor assessment of workload (low and high load)
- Poor HMI design to support during critical situations or poor design to present safety critical information, Poor consistent HF design across different systems
- Poor organizational knowledge of HF and need for HF in the organizations. Knowledge and awareness of Human factors seems poor in the responsible organisations. Human Factors are often conceptualized as physical ergonomics (layout and working environment) and necessary steps to perform cognitive analysis and organisational analysis are not done. Human factor knowledge is usually outsourced, and necessary key knowledge is not integrated in the responsible organisations. To ensure the right competence, there are several HF certification schemes internationally, such as Centre for Registration of European Ergonomists (CREE) and Board of Certification in Professional Ergonomics. (However there is no systematic certification of Human factors experts in Norway, there is now one certified HF expert in Norway.)
- Poor knowledge and awareness of HF, poor certification of HF experts Training and certification seems wanting in Norway.
- Missing use of HF standards. There is missing knowledge of a required set of Human Factors tools, guidelines and theories. In some instances new projects has not been aware of a simple set of human factors guidelines, thus it seems important to focus on standards such as ISO 11064 (2013), HF guidelines for the use of CCTV, guidelines for team training as CRM (Crew Resource Management).

4.3 Conclusions and recommendations to improve HF integration in early phases

As discussed by Rasmussen (1997), risk management is based on a complex relationship between regulators, organizations and actors thus our conclusion is that HF must become more in focus through coordinated actions on many levels. The knowledge and focus of human factors is too weak and should be explored in the "byer" organizations and environment (authorities, educational institutions and research council), and simple set of HF guidelines and standards should be used to ensure early HF focus, in addition to continued regulatory focus and review. Several mitigating actions should be performed in order to improve HF, safety, and resilience:

- The organizations involved in design and operation should employ HF experts within own organizations, in order to create stronger focus and ownership
- Common HF design should be an early requirement from the concept phase and onward, such as common HMI and user interfaces, to ensure consistent HF and HMI across different suppliers
- Cognitive and organizational factors should be prioritized and validated/verified in

the early phases of all projects (i.e. from PUD through conceptual design and feed phase). Cognitive factors and organizational factors are important both to sustain safety and avoidance of major disasters, but also to sustain resilience and a positive work environment thus these elements should be prioritized.

- External validation and verification from certified HF experts should be performed as early as possible.
- Improved design of Human Machine Interface (HMI) to present safety critical information, improved design of alarms, improved design to accommodate stressful situations
- Exploration of critical scenarios prior to the design phases, in order to ensure that the workplace support critical and normal scenarios/ operation

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