Are Cognitive and organizational human factors missing from the blunt end in the oil and gas industry?

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Abstract: The area of Human factors (HF) has been in focus to increase safety and quality of operation in the industry. HF covers three main domains, physical ergonomics, cognitive factors and organizational factors. HF has often been identified as root causes in accidents, i.e. 40-90% in different industries. The International Association of Oil & Gas producers (OGP) prioritized "more attention paid to HF" as one of four issues after the Macondo disaster in 2010. However in several projects, HF focus on cognitive factors and organizational factors is missing in the blunt end (i.e. early phase). HF is conceptualized as physical ergonomics (work environment and layout). In addition layout is often based on prior experiences and not on new was of operations. There is poor systematic HF education; few HF experts in user organizations and limited HF research to improve safety. We propose that HF must focus on cognitive factors and organizational factors early from the blunt end. The organizations should have local HF competence. External validation and verification from certified HF experts should be performed early. A simple set of HF guidelines and standards should be used to ensure HF focus, in addition to continued regulatory focus and review.

Keywords: Human Factors, Safety, Resilience, Crew Resource Management.

1. INTRODUCTION

In the last 60 years, Human factors (HF) have been developed as a discipline, covering a broad set of domains. Traditionally the main domains have been physical ergonomics (consisting of layout, work environment..), cognitive factors (perceptions, information processing, Human Machine Interface..) and organizational factors (communication, teamwork, Crew Resource Management..), see [1]. HF has an important influence on work design and execution, and thus it has a key relationship to safety. In many reviews of accidents, HF has been seen as a causal or contributing factor in 40 to 90 percent of accidents, depending on the industry, [2], [3], [4], [5]. Thus human factors has been key area in design and operations of safety critical equipment, this has been particular evident in aviation, where human factors experts has been a key part of the organization and in design teams. The oil and gas industry have a different tradition related to HF, in many instances HF has often been considered at later stages, and not from the blunt end i.e. early in the concept phase. Recent accidents and incidents have created more focus on HF in the oil and gas industry, i.e. a reactive approach. The Macondo blowout killed 11 workers, released 4.9 million barrels of oil, and expenses are 42Bn$ so far. More focus on HF, such as a better design (or improved human machine interface) 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, see [6]. In the oil and gas industry in Norway, there has been a focus on physical ergonomics i.e. layout and work environment, based on regulation, from PSA [7], the Facilities regulation §20 – focusing on ergonomic design, and §21, focusing on HMI. When designing a control center or a drilling cabin in the oil and gas industry, some human factors issues are usually explored and discussed. This has been done based on the use of recognized HF standards such as ISO 11064 "Ergonomic design of control centers", [8], and exploring alarm standards from EEMUA, [9].

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Cognitive factors and organizational factors are not always explored sufficiently, and have sometimes been identified as areas of consideration or causes in incident investigations, [10] and [11]. A review of plans for new oil and gas fields (PUD), identified that mainly physical ergonomics was in focus at the early phases. Several cognitive and organizational issues in the drillers workplace was identified by the PSA, ref [12] [10] indicating insufficient focus on HF both in design and operations. Insufficient focus on human factors has also been identified in the design phase during implementation of new automated technology in drilling, ref [13]. Insufficient cognitive focus has also been identified in a design review of four new control centers, 2010 through 2012. The missing focus on cognitive issues and organizational issues may create weaknesses and holes in defenses as described in [14] and [15].

Based on the above factors, the research questions we would like to discuss are:

- Are key HF issues such as cognitive factors and organizational factors prioritized as a part of design of new control centers, i.e. from the blunt end?
- Why are cognitive and organizational human factors missing from the blunt end?
- Do the responsible organizations have sufficient knowledge to require, buy and involve the relevant HF experts at the right time?

2. METHOD AND RESEARCH

The research questions mentioned above have indicated the need for the following activities:

- A review of status of HF in critical areas, as documented by reviews by the authorities, and an exploration of key challenges related to actual implementation of HF issues by interviewing the HF actors involved in the design process
- A participatory review of HF focus in the recent design of control centers, i.e. an evaluation of the focus on physical ergonomics, cognitive factors and organizational factors. The reviews have especially been focused on new ways of operation based on remote operations and increased collaboration between onshore and offshore, i.e. if HMI has been designed on new responsibilities and if there has been focus on collaboration in distributed teams such as explored by crew resource management training (CRM).

The areas of exploration have been design of the control centers, based on recognized human factors standards, such as ISO 11064 [8], implying a task driven iterative design process.

The research approach when reviewing the control centers have been based on participatory action research (PAR); see [16]. 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 helped prioritize the findings. The study has focused on the blunt end, i.e. early design phases (feed phases) and during detailed design, when implementing new solutions or integrating several systems.

We have also explored the need for standards and guidelines through a Norwegian human factors network, consisting of around 400 stakeholders, having been involved in relevant projects where Human factors has been a key issue, see www.hfc.sintef.no.

3. RESULT POOR FOCUS ON COGNITIVE AND ORGANIZATIONAL FACTORS

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

3.1. Review of prior evaluations and incidents

We have performed a review of status based on open incident reports from the authorities and OGP.

From PSA, [12], 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), there was a mix of old and new systems, and 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.
From PSA, [10], 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. It seems there had not been any notable improvement in the period from 2007. 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 CCR, 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.

In the design phase, the system selection, 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.
HF in Crane cabins can also be improved, related to cognitive issues (Graphical displays, and 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 report [11], 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 escalate an incident.

The research and development in the oil and gas area, including safety and HF, is handled by the Norwegian PETROMAKS program. In the 10 year period, documented by Research Council [17], 447 projects had been awarded grants – around 1%, i.e. 4 minor projects were related to Human Factors. This indicates poor HF focus related to research and exploration of new technology in the oil and gas industry.

The reports and cases indicate that there are challenges related to cognitive and organizational human factors, and support the view from OGP [6] –"more attention paid to HF", and it is suggested that HF should be more in focus in the blunt end in the early phases. Key issues are suggested to be:

- Requirements of common HF design, such as HMI and user interfaces should be performed as early as possible, to ensure consistent HF and HMI across different systems from different suppliers
- Improved design of Human Machine Interface (HMI) to present safety critical information, improved design of alarms, improved design to accommodate stressful situations
- Exploration of "worst case" scenarios prior to the design phases, in order to ensure that the systems at the workplace can accommodate worst-case scenarios even in a stressful situation

3.2. Varying focus on organizational HF and team collaboration, Crew Resource Management during the design phases

In the oil and gas industry it has been increased focus on collaboration between onshore and offshore through initiatives such as integrated operations (IO), as described in a white paper, **[18]**. The implementation of IO creates the need for improved collaboration and coordination between onshore and offshore, thus it was suggested in [19], that the Oil and Gas industry in Norway, should implement an adapted Crew Resource Management (CRM) training. The need for CRM training has been based on a 6th generation CRM concept, ref [20], identifying/preventing threats to safety at the earliest time and managing errors (i.e. Threat and Error Management). The CRM topics have been conceptualized as communication, situational awareness, teamwork, decision making, leadership and personal limitations (stress). Since 2005 the need for CRM training has also been a part of a HF validation method, called CRIOP, ref [21], The CRIOP validation method is often used in the oil and gas industry when building control rooms, control centers or driller cabins. The CRIOP method is an open, freely available method from the web (www.criop.sintef.no).

The need for CRM training among the crews involved in drilling and operations between onshore and offshore have been explored during the validation of design and operation of new control centers. The validation activities have been based on participatory action research (PAR) in the different phases of design. Meetings, discussions and prioritization of issues were conducted in a group setting, involving between 6and 26 participants in the different projects. Participants were HF experts, management, technical safety, work environment, automation, telecom and control room users. We have been involved in a limited set of validation activities, and we have performed analyses of 10 control centers as a part a verification and validation activity, and exploring two centers with collaboration between drillers, onshore support and expert centers more in depth.

The two analysis of collaboration between drillers, onshore support and expert centers were based on extended observations, interviews and discussions. Collaboration between the driller's onshore operation center and the different oil rigs were impacted by the variability of procedures and systems between rigs from the same operator. There was little standardization of procedures between the different rigs. Between the onshore support centers and onshore expert center, there were poor common perceptions missing communication and missing support of situational awareness.

In one operational setting (i.e. assessment of the control centre in operations) there were 15 operators involved in the control center. 30 % of the control room operators wanted to discuss problems and challenges in a team setting (needed access to experts locally or onshore) – and in one instance ”13% - only 2 of 15 operators was confident that they could handle the CCR on their own (87%", i.e. 13 of 15 was not confident that they could handle incidents.) This also supported the need for systematic CRM training.
During the verification and validation activities, the participants prioritized issues and findings through expert judgments. In 6 of 10 projects, some sort of CRM focus and training was explicit suggested and prioritized (such as collaboration and communication) by the involved experts. The CRM focus or training was seldom suggested so early that it impacted the HMI design or layout.

The CRM issues discussed during validation and verification were related to design of procedures and systems for collaboration in a distributed team between onshore and offshore. Issues were clarity in responsibility, design for situational awareness in a distributed setting; how to support common mental models, common risk perceptions, Common HMI across different systems placed onshore and offshore and supporting communication in a distributed setting.

In Norway the need for CRM training has been suggested from 2005 at least. The need for CRM was prioritized in 6 of 10 projects we explored, thus the users have seen the need for CRM training. Based on accidents, such as Deepwater Horizon, OGP [23], has recommended implementing CRM training in a wide range of wells operational roles. A systematic approach has not yet been implemented in the oil and gas industry, thus there is a need to prioritize CRM in the industry. It may be a sign of complacency that it takes 10 years to implement necessary HF based training regime in the oil and gas industry.

3.3. Varying focus on HF during the design phases – poor focus on cognitive HF and organizational HF – when new ways of operation were explored

The focus on HF, to support safety and resilience has, been explored in four projects covering the design of control rooms (workplace design and HMI) involving remote operations and report support. The HF standard ISO 11064 [8] was used as a context for the work.

The activities has been based on participatory action research (PAR); exploring "best practices" guidelines and using a scenario approach in the early phases of design. Meetings, discussions and prioritization of issues were conducted in a participatory group setting, involving between 6 and 26 participants in the different projects. Participants were HF experts, management, technical safety, work environment, automation, telecom and control room users. The following common issues were identified between the projects:

- Physical ergonomics: Issues related to layout and work environment were minor. The quality of voice communication between distributed actors could be improved. However layout was often based on prior solutions – and not based on new ways of operation and new possibilities.
- Organizational ergonomics: Responsibility, work procedures and information between distributed actors should be clarified and had not been explored sufficiently. In addition, the expert teams involved in verification and validation prioritized increased focus on team collaboration and suggested adaptions of Crew Resource Management (CRM) training.
- Cognitive ergonomics: HMI development has been immature, and should be specified more clearly by the users, developed based on user requirements 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 remote support has not been based on HF guidelines. During not normally manned operations (NNM) when humans are not present - how can the 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? These questions had not been explored sufficiently.

It was varying HF knowledge and awareness between the four different companies having the responsibility of the installation. Only one operator had a broad set of Human factors experts integrated in their organization. The other operators had outsourced Human Factors activities, and when discussing cognitive and organizational issues the operator used a physical ergonomics as a reference, that had scant knowledge of the area. It was varying (i.e. missing) Human Factors knowledge in the project teams. 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 missing systematic certification of Human factors experts in Norway, so far there is one certified HF expert in Norway.

We have also seen instances of missing human factors focus during the initial phase of relevant projects even at this point in time, i.e. 2013. In [13], it was found that there was insufficient focus on human factors in a design phase of new automated technology, i.e. the design process of new drilling equipment.

4. DISCUSSION AND CONCLUSION

We have seen that there are varying practices related to the implementation of HF in the blunt end, prior to design. In some projects - cognitive human factors, such as human machine interfaces, responsibilities and procedures are not prioritized. When discussing the key theme of this article

"(Why) Are Cognitive human factors missing from the blunt end in the oil and gas industry?", our position is:

- Missing proactive focus on cognitive human factors and organizational factors. It is a great deal of variability, but in several projects in the oil and gas industry (cases from drilling), cognitive and organizational human factors is missing from the blunt end i.e. in the early project phases.
- Missing knowledge of the scope of human factors. Knowledge and awareness of Human factors seems poor in the responsible organizations. Human Factors are often conceptualized as physical ergonomics (layout and working environment) and necessary steps to perform cognitive analysis and organizational analysis are not done. Human factor knowledge is usually outsourced, and necessary key knowledge is not integrated in the responsible organizations. 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 a selected set of standards such as ISO 11064 [8], HF guidelines for the use of CCTV, guidelines for team training as CRM (Crew Resource Management).

As discussed in [22], risk management is based on a complex relationship between regulators, organizations and actors thus HF must become more in focus through coordinated actions on many levels. 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. We propose that HF analyses and work also must focus on cognitive factors and organizational factors. The knowledge and focus of human factors should be explored in the "byer" organizations and environment (authorities, educational institutions and research council), and cognitive and organizational factors should be prioritized and validated/verified in the early phases of all projects (i.e. conceptual design and feed phase). External validation and verification from certified HF experts should be performed as early as possible. A simple set of HF guidelines and standards should be used to ensure early HF focus, in addition to continued regulatory focus and review.

HF focus should be proactive and not only reactive as a result of an accident investigation.

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