Safety Science xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Remoteness and sensework in harsh environments

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ARTICLE INFO

Article history:
Received 3 June 2015
Received in revised form 17 February 2016
Accepted 20 March 2016
Available online xxxx

Keywords:
Remote operations
Integrated Operations
Sensework

ABSTRACT

There is a general trend of more distributed work configurations in many work domains, examples being air traffic management and telemedicine. As the offshore petroleum industry conquers increasingly remote and harsh areas, there is a pressure towards lower offshore staffing and more sensor-based onshore management. This introduces new challenges of control and safety. Integrated Operation (IO) addresses many of the challenges associated with remoteness. IO denotes an operating philosophy where new technologies and work processes make possible an increased use of real-time data and collaboration across geographical distances and professional disciplines. It presupposes clearly defined work processes, and a strong division of labour with respect to decision making and execution. In this article, interpretation work, decision making and execution are investigated through the lenses of *sensework*. Sensework denotes sociotechnical work in safety–critical operations where groups of professionals try to put together pieces of information to give meaning to familiar and unfamiliar situations. The division of labour and the envisioned decision making processes of IO build on assumptions that are not necessarily valid for distributed sensework in remote areas or modes. Sensework is characterised by close, iterative interaction with nature through the use of sensor data and digital representations, implying that decisions are problematic to make for experts that are not really engaged with the operational context. There is a need for more research on and refinement of models for operating in remote areas or modes. In particular, there is a need for harmonisation between technological solutions and organisational arrangements.

1. Introduction and objective

Hazardous activities in harsh environments represent a double challenge; not only does one have to manage the inherent risks associated with the hazardous activity itself, but additional environmental and operational conditions that may affect the operations in known and unknown ways must also be managed. An example of this is the expansion of petroleum operations to the high north (Verhelst et al., 2010). In this situation, well-known risks connected to drilling and production operations are reinforced and extended by physical and operational conditions associated with geographic (including geologic) and climatic (including hydrographic) circumstances, making necessary operation from a distance – a higher degree of onshore management of offshore installations. While physical conditions refer to environmental aspects such as temperature, wind, ocean depth, pressure, remoteness and material wear, operational conditions in this paper refer to challenges of remoteness, associated with division of labour and decision making hierarchies. The paper addresses some particular challenges of *remoteness* and its *operational and organizational consequences*.

Remoteness induces challenges with respect to staffing, information management and organising of operations. Long distances and significant travel risk and expenses are drivers for low staffing. One way of compensating for this is to automate tasks that are currently being done by humans, in addition to reducing the organisational redundancy represented by arrangements where the same tasks are allocated to more people than the minimum requirement would suggest. While the primary objectives of the operations usually remain unaltered, such re-definitions of tasks and staffing must be accompanied by a re-examination of the way tasks and resources are being coordinated. In complex sociotechnical systems, humans are seldom replaced by systems and machines without triggering the need for new kinds of work involving human judgement, often at other locations such as control rooms, centres of coordination and the like. To facilitate this, the division of labour and even the foundational operating philosophy will also often have to be established anew.

While remoteness may be considered as an extreme environment in itself, remoteness is always relative to how one chooses to organise operations and locate different functions, hence it may be more adequate to speak of remoteness as a *response* to the harsh environment (infrastructural and environmental conditions).

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http://dx.doi.org/10.1016/j.ssci.2016.03.020
0925-7535/

In the petroleum industry, great water depths, reservoirs of high pressure and high temperature, and a notorious uncertainty with respect to what kinds of formation and formation characteristic the crew will drill into next, represent conditions that become increasingly challenging as remoteness of operations increases. In many respects, Integrated Operation (IO) is the petroleum industry's response to many of the challenges of harsh environments. IO is an operating philosophy and an operating regime in the petroleum industry involving aiming to develop the technological and organisational capabilities to make better use of real-time data, facilitating for work processes that rest on better and more radical division of labour, sensor-based management and digitally enabled integration across professional boundaries, geographical distances and organisations. The main goal is to ensure faster, better and safer operations. While IO has become the commonly used terms for this process in Norway, similar developments elsewhere are frequently referred to as field of the future, smart fields, iField, digital oil fields, e-field, intelligent energy and digital energy. The body of research on IO and safety is young, but growing (e.g. Albrechtsen and Besnard, 2013; Andersen et al., 2010; Droivoldsmo et al., 2007; Grøtan et al., 2010; Haavik, 2013; Hollnagel et al., 2010; Johnsen, 2012; Kaarstad and Rindahl, 2011; Rosendahl and Hepsø, 2013; Tveiten, 2014).

A traditional assumption in the petroleum industry that has survived the transition into IO, is that operational decisions take place at a certain stage of a linear process of monitoring, interpretation, decision making and execution, and that division of labour should reflect the stages in this process. Consequently, an envisioned, ideally organising principle of IO is that interpretation work and decision making should be allocated to the experts onshore, while the offshore community merely shall execute the decisions (Droivoldsmo et al., 2007).

The challenges experienced by the petroleum industry represent a case of a more general trend of distributed work in high-risk domains. Interoperable global ATM systems (see e.g. Malakis and Kontogiannis, 2014) and telemedicine (see e.g. Nicolini, 2007) are examples of other domains where remote operations will be increasingly common in the near future. This paper investigates the unfolding of the interrelated work of interpretation, decision making and execution in the domain of offshore oil and gas exploration where harsh environment and remoteness of operations induce requirements for low offshore staffing and high degree of sensor-based monitoring, combined with support and management from remote centres of coordination. The analysis is believed to also have generic value, hence the analysis could also be read as an analysis of remote operations in general, although particularities of the different domains are important to consider in separate analyses.

To guide the investigations, the following questions are pursued: (1) What characterises work where highly inaccessible, risky phenomena are managed by a distributed organisation, and (2) what does this imply for the decision structures and safe management of future operations where sensor-based management, remoteness and division of labour is envisioned to increase further? The article contributes to the understanding of the challenges of and responses to remote operations, and the alignment of the IO philosophy and approach with recent developments on interdisciplinary, sociotechnical work in safety–critical operations, under the label of *sensework*.

2. Sensework

The volumes of data – and the technologies to produce these data, circulate them among an increasing number of potential and actual users, and visualise them to make them communicative and intelligible – have been rapidly growing in many work domains over the last decade. Two such work domains are the oil and gas industry (Haavik, 2014b) and the health sector (Haavik, 2016), who both have received much attention these years as sociotechnical innovation has been sought through initiatives of Integrated Operations (IO) and telemedicine respectively. Through the Norwegian based, but internationally oriented joint industrial and research initiative Centre for Integrated Operations in the Petroleum Industry, efforts have even been made to identify and draw on commonalities between these domains in projects on telemedicine for IO (Fernandes et al., 2014a, 2014b). With the rapid and foundational sociotechnical developments, there is a need for safety research to catch up and stay relevant also in the high-risk high-tech domain. This development generates a need to scrutinise the organising of work to align work practices with the changing technological context.

Sensework has recently (Haavik, 2014b, 2016) been introduced as a label for a type of sociotechnical work in safety–critical operations where groups of professionals work to configure heterogeneous information sources including digital sensor data and different sorts of representations into coherent pictures that gives meaning to familiar and unfamiliar situations. We shall return to elaborate more on sensework after a brief review of some well-established perspectives on decision-making and sensemaking in the research literature that sensework relates to, but differs from.

Organisational structures of authority and decision making represent one central, long-lasting discourse in the safety field, with the perspectives of Normal Accident Theory (NAT) (Perrow, 1984) and High Reliability Organisation (HRO) (La Porte, 1996; La Porte and Consolini, 1991; Weick, 1987; Weick and Roberts, 1993; Weick and Sutcliffe, 2007) and the prospects of the organisation being able to spontaneously reconfigure from a centralised to a decentralised decision structure during crises serving as central references. Unfortunately the somewhat reductionist view that NAT and HRO represent technology determinism (e.g. Hopkins, 2001) and social constructivism (e.g. Rochlin, 1999) respectively has impeded a fruitful debate. A more serious elaboration on the synergy between the perspectives could perhaps have led attention towards the heterogeneity of organisations and decision structures, where the social sphere and the technological sphere are deeply interwoven.

Also the research agenda and approaches in the fields of decision making and sensemaking to account for and provide recommendations for managing high-risk operations are required to keep up scientifically with the rapid developments in the world of practice. Although the research focus for decision making theory to a large extent has shifted from a focus on rational choice (Simon, 1956) via bounded rationality (Cyert and March, 1963; March and Simon, 1958; Simon, 1957) to organisational sensemaking (Weick, 1995, 2001), decision making in a resilience perspective (Woods, 2003) and naturalistic decision making (Klein et al., 1993; Lipshitz et al., 2001; Zsambok and Klein, 2014), there is a strong tendency to address work and safety from a cognitive perspective – individual or social – without bringing the material and technological circumstances in as intrinsic elements of and context for a more distributed cognition. While Weick (1995) and Weick et al. (2005) criticises the use of the decision making term for often referring to processes that really are interpretation work and sensemaking, the lack of focus on the materiality and technology associated with the generation, management and interpretation of data is striking. Also Klein's perspective on cognition as an individual process that takes place in teams does not bring in the rich sociotechnical heterogeneity of cognition that Hutchins (1995a, 1995b) has portrayed so well, into the discourse.

There is still a significant potential for more actively drawing on methods and insights from fields outside the traditional safety science domains that have invested much effort to explore how

Please cite this article in press as: Haavik, T.K. Remoteness and sensework in harsh environments. Safety Sci. (2016), http://dx.doi.org/10.1016/j.ssci.2016.03.020