

What inter-organizational factors are related to risk of major accidents in offshore operations?

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Abstract: The purpose of this paper is to present the ongoing research project *Inter-organizational complexity and risk of major accidents*. In the petroleum industry, increasingly complex drilling conditions have resulted in a demand for more specialized services and an increase in outsourcing of operations to external actors. The result is complex organizational systems consisting of multiple organizations in close collaboration and operations that span across several organizational boundaries. Inter-organizational complexity is an emerging trend in the industry; however, there has to date been little research on the effect of inter-organizational complexity on safety and risk of major accidents. The main objective of this project is to expand our knowledge and understanding of safety issues in drilling and well processes that are characterized by high inter-organizational complexity.

The project aims to investigate in what way safety issues are related to formal and informal coordination of work in inter-organizational systems, conditions for safety effects of knowledge sharing within and between organizations and management and safety effects of inter-organizational industrial relations. Our objective is that the research will contribute to new knowledge and new methods that can reduce risk and increase resilience in the petroleum industry.

Keywords: Major accidents, Petroleum, Coordination, Human Factors

1. INTRODUCTION

The petroleum industry is a high-risk industry where complex operations are carried out in perilous and unforgiving environments, and seemingly negligent mistakes may have disastrous, wide-ranging consequences. Consequently, safety is highly prioritized in oil producing companies. The use of contractors and sub-contractors has expanded significantly in the recent years, and due to technological advances in the industry catalyzed by a development towards more complex reservoirs and deeper wells, outsourcing operations to external actors has become more common [1, 2]. The result is complex organizational systems where multiple actors collaborate closely in operations across and within organizational boundaries [3, 4]. *Inter-organizational complexity* is an emerging tendency in the petroleum industry and the progress towards increasingly complex inter-organizational systems raises an important question: How does this trend reflect on safety and risk of major accidents?

According to the Petroleum Safety Authority Norway (PSA), a major accident can be defined as “*an acute incident, such as a major explosion, which immediately or subsequently causes several serious injuries and/or loss of human life, serious harm to the environment and/or loss of substantial material assets*” [5]. Major accidents in the petroleum industry are fortunately rare, but disasters such as the capsizing of the Alexander L. Kjelland platform in 1980, the explosion on Piper Alpha in 1988, and the more recent blowout in the Macondo field in the Gulf of Mexico, 2010 remind us that consequences entailing major accidents in petroleum activities can be adverse and have resulted in a strengthened focus on major accident prevention. In Norway, major accidents represent an important priority area in the research strategy of the Norwegian Research Council (PETROMAKS HSE-program) [6].

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Safety research in the petroleum industry has to little extent addressed the challenges related to inter-organizational complexity, even though a number of investigation reports of incidents and major accidents in the industry have identified factors relating to the involvement of multiple organizations as underlying (for example the well control incident at Gullfaks C on the Norwegian Continental Shelf in May 2010 [7] and the Deepwater Horizon accident in April 2010 [8, 9]). With an expected increase in technological challenges and need for specialists due to old and depleted fields, deep-water drilling, and use of automated systems, inter-organizational complexity is likely to increase. Knowledge generated from research addressing these issues is thus fundamental, and based on this acknowledgement; the current project will study the potential for major accidents in complex inter-organizational processes in drilling and well activities.

In this paper, we present an on-going research project on safety and inter-organizational complexity. The paper will start with a presentation of the research project as a whole and the theoretical background for the project, before moving on to more specific parts of the project that we are currently working on.

2. DESCRIPTION OF RESEARCH PROJECT

The ongoing research project *Inter-organizational complexity and risk of major accidents* is a collaborative study between The Norwegian University of Science and Technology (NTNU) and The International Research Institute of Stavanger (IRIS) (project owner). This paper will primarily cover the NTNU-part of the project. The project is funded by the Research Council of Norway as a part of the PETROMAKS HSE program. The main objective of this research priority area is to further knowledge of sectorial challenges in the petroleum industry and develop solutions to reduce risk. In this regard, one of the central themes is major accidents [6]. The project commenced in August 2013 and is to be concluded by August 2016.

2.1. Objectives

The project aims at investigating the effect of inter-organizational complexity on safety and risk of major accidents. The overarching aim is to expand our knowledge and understanding of safety issues in drilling and well work processes that are characterized by technological complex operations and inter-organizational complex relations. Our intention is that the knowledge generated from this project can be utilized to improve safety in the industry and will contribute to safety initiatives that help prevent major accidents in the future. In order to attain this goal, the following objectives have been set:

- 1) Increase our understanding of inter-organizational relations in drilling and well activities. This includes knowledge concerning work process organization and identification of safety challenges associated with the division of work between operator and contractors.
- 2) Utilize the knowledge to provide input to development and improvement of regulatory standards and administrative responsibilities within the industry.
- 3) Utilize the knowledge to provide input to development and improvements of organization and administration of work processes involving several companies (operator and one or several contractors).

3. THEORETICAL BACKGROUND

Most studies on safety and major accidents have been conducted in intra-organizational settings, where safety issues are investigated within the boundaries of a single organization. The involvement of multiple organizations represents an important contextual characteristic of the petroleum industry and implies that safety issues also may occur in the interfaces between different companies. There has to date been few studies that include factors across organisational boundaries, however some exist. Kongsvik et al., addressed inter-organizational safety issues in the petroleum industry in a qualitative study [10]. Also, Garner provides an investigation regarding the role of NASAs inter-organizational network in the Columbia space shuttle accident [11]. Safety issues in inter-organizational complex relations have also been identified in other industries such as construction [12, 13], mining [14], offshore transportation [15] and aviation maintenance and maintenance of military equipment [16]. Other studies address inter-organizational safety issues in relation to outsourcing. For instance, Jeffcott et al., identified safety challenges in railway operations as a result of the privatization of British Railway [17], and Jonnstone, Mayhew and Quinlan [16] present three cases where accidents were linked to errors and understaffing of independent contractors. Additionally, a literature review conducted by Quinlan, Mayhew & Bohle [18] indicates a negative association between outsourcing and occupational health and safety. These studies illustrate the need to further explore inter-organizational factors in relation to safety.

3.1. Inter-organizational perspective

In order to increase our knowledge of safety in inter-organizational complex systems in the petroleum industry, the project will draw on general literature in management and organization studies. Recently, there has been an increased emphasis on issues such as inter-organizational cooperation between companies and production collaborations and work processes that extend beyond the boundaries of the formal organization. In many cases, operations and work processes are not confined within one formal organization where the employees are co-workers from the same unit, but rather, many activities involve employees from many different organizations. Providers of specialized services and subcontractors are often in close cooperation with the operating company, and managers, employees, resources and competences are tightly knit together [3, 4]. Arguably, to understand safety issues in an inter-organizational setting, it is important to move beyond a conservative view of safety within the single organization with definite organizational boundaries, towards an understanding of safety that recognises the potential for safety issues arising in the interplay between organizations. There are several areas concerning inter-organizational collaborative work where safety issues can occur. A larger number of contractors and external suppliers suggest increased interaction between units and employees from different organizations. In this respect, aspects such as sharing of resources, coordination of common activities, training, development and implementation of routines and procedures across companies and communication become more complex because a number of different interfaces have to be coordinated [19, 20].

3.2. Normal accidents theory and High reliability theory

In safety research, a growing body of literature has addressed the effect complexity of organizations, technologies and activities can have on safety. There are two main theoretical perspectives addressing safety management in complex, high-risk organizations: Normal Accidents Theory (NAT) [21] and High Reliability Theory (HRO) [22]. The former derived from Perrow's investigation into the accident at Three Mile Island, where the combination of complex technology and tightly coupled inter-dependent systems resulted in a partial meltdown with major accident potential. NAT postulates that accidents are inevitable in systems that are both interactively complex and tightly coupled, such as petroleum installations. As long as the system remains highly complex and tightly coupled, accidents are bound to happen. Accordingly, from this perspective, the only way to reduce the risk is either to reduce complexity or make the components less interactively dependent. In inter-organizational complex systems, such as a petroleum installation, the involvement of multiple organizations implies

an increased level of complexity. In this view, major accidents in the petroleum industry will be exceedingly difficult to avoid in the future.

Studies of *high reliability organizations* (HROs) have challenged the postulations of NAT. HROs are both highly complex and tightly coupled, but have nonetheless sustained exceptional safety records over a long period of time. According to Weick and Sutcliffe [22, 23], HROs are learning organizations characterized by a set of cognitive practices that enable people to work safely and eventually creates mindfulness and reliability. These practices involve: constantly tracking and investigating small errors, resisting oversimplification, sensitivity towards current operations, committing to resilience and finally, deferring to experts. HRO research can be said to represent a focal shift in safety research, where the focus is on success, not on failure. Arguably, HRO perspective represents a valuable addition to safety research, and we believe that combining the HRO perspective with theories on inter-organizational complexity will constitute a nuanced theoretical foundation for exploring the research questions.

3. RESEARCH AREAS AND METHODOLOGY

The project as a whole encompasses three main areas of research:

- 1) How safety issues are related to formal and informal coordination of work in inter-organizational systems
- 2) Conditions for and safety effects of knowledge sharing within and between organisations.
- 3) Management and safety effects of inter-organizational industrial relations.

The foundation for focusing on these areas is that they have been found to be important in investigations of incidents and accidents in the industry [7, 8]. The first research area is related to issues such as overlaps between different management systems, coordination of process/work descriptions, standards etc. The second research area involves challenges and issues relating to knowledge sharing and learning such as learning from accidents and incidents, information and knowledge exchange, utilization of existing experience and knowledge. Finally, key issues in the third research area involve decision making and cooperation between employees and employers from different companies and how these influence safety.

In order to answer the research questions, a mixed methodology approach is employed. We plan to undertake 40-50 semi-structured interviews and two surveys. Data will be sampled from two operating companies as well as significant contractor and sub-contractor companies. With regard to the research context, we have chosen to focus on drilling and well processes. The reason for this is that the drilling and well context enables us to study work processes where the operations involve use of complex technology, where the consequences for errors can be severe and where employees from multiple organizations cooperate closely. Consequently, the drilling and well context is highly relevant with regard to major accidents.

We are currently undertaking a study within the first research area. This study constitutes a part of a PhD-project. In the following sections we will present this ongoing work.

4. THE CURRENT STUDY

The current study aims at investigating safety issues related to coordination of work in petroleum installations. The objective is to gain a better understanding of what coordination challenges arise in drilling and well processes and how such issues are related to major accidents.

Research has shown that coordination of work is challenging with the involvement of multiple organizations [10, 13, 14] and there are several examples from investigation reports where lack of adequate coordination between organizations has been associated with the occurrence of major accidents [7, 9, 11]. Coordination of work in an inter-organizational setting may involve several safety challenges and we argue that it is an important area to explore, especially in relation to major accidents.

When speaking of coordination of work in an intra-organizational setting, elements such as grouping of activities, level of decentralization, rules and standardisation of work processes and implementation of formal procedures become relevant. However, in an inter-organizational setting, it can be anticipated that these elements are much more complex and may also involve additional issues than those occurring in intra-organizational work. Research has shown that inter-organisational complexity and tightly coupled technologies are difficult to manage, and cannot be completely controlled by a centralized organisation and formal mechanisms [7, 24]. That is, procedures and guidelines are to some extent general, which means that they do not describe every task in every context that might occur. A number of choices and adjustments therefore have to be made during daily work. Furthermore, multiple organizations also imply the existence of different management systems with different work descriptions and formal procedures. Issues such as overlaps between management systems, confusion regarding responsibilities and goal conflicts have been identified in research as challenging [10, 13, 14]. Accordingly, understanding in what situations such choices have to be made and how overlaps are handled between organizations is important. In this regard, relevant research questions include:

- How do the existence of different management systems impact safety in drilling and well activities?
- To what extent and in which situations are the operator vs. the subcontractors' management systems used?
- How are overlaps and boundaries between the management systems of involved companies handled?
- To what extent are issues of overlap and (in)compatibility of governing documents and work process descriptions described in the formal contracts between the companies?
- Do employees in the core of operations act according to procedures and work descriptions?
- How do dilemmas and domain conflicts between aspects of governing documents influence employees' and managers' actions?
- To what extent do inter-organizational formal and informal systems/mechanisms vary across subcontracts and type of activity?
- How do people at lower levels in the organizations develop work practices that support safety?
- What are the main challenges of developing HRO work practices in inter-organizational systems?

4.1. Phase 1

In the preliminary phase of the study we are currently undertaking a review of literature addressing safety in inter-organizational systems. The aim of this on-going work is to explore the empirical literature concerning safety in an inter-organizational setting in order to obtain an overview of the extant literature and to map out areas that have been neglected in research. So far, we have conducted a literature search. The literature was collected by means of searching electronic journals (ISI web of science, PsychINFO and Google Scholar), in addition to going through reference lists of relevant publications. The search resulted in a total of 15 articles. A thematic analysis of the literature is currently being undertaken.

In addition to this, we are also reviewing investigation reports of accidents in drilling and well operations in Norway. This will hopefully provide us with a clearer picture of which situations are related to safety challenges and what kind of accidents and unwanted incidents such situations has result in. The information provides a basis for the interview guides to be used in the second phase of the study.

4.2. Phase 2

The second phase of the study will be based on qualitative data from semi-structured interviews. Here, the information from phase 1 will be utilized in order to determine what scenarios and situations we should focus on in the interview guides. Because research concerning safety and major accidents in an inter-organizational perspective is limited, the qualitative data will be valuable in the sense that it provides in-depth information of what safety challenges are related to coordination of work in an inter-organizational setting. The data will be analysed using *Grounded theory* (GT) [25]. Taking into consideration the explorative nature of the study, grounded theory is suitable because it enables us to approach the material with open and general research questions. It is an inductive and systematic method where the overarching aim is to develop a theory that is grounded in the data. Data collection and analysis are parallel processes and are done simultaneously. The analysis consists of several predefined steps, where the essence of the process involves systematically coding the material into a final set of categories that is considered to be the foundation of the developing theory.

5. CONCLUSION

Inter-organizational complexity constitutes an important contextual feature of the petroleum industry, and to date there has been limited research in this area. Seeing that investigation reports of incidents and accidents in the industry have linked inter-organizational factors to the occurrence of major accidents, and that increasingly challenging drilling conditions is likely to prompt more complex organizational structures, we argue that generating knowledge on the effect of inter-organizational complexity on risk of major accidents is highly relevant in order to prevent major accidents in the future.

We believe the presented research project will contribute to a better understanding of major accidents in the petroleum industry. Furthermore, our aim is that this knowledge can be utilized to develop new methods directed towards prevention of major accidents, and eventually will contribute to reduce risk and increase resilience in the industry.

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