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Integrated Operations – Challenges due to technology reliance in collaboration

A qualitative case study

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ABSTRACT

This study explores implications of Information and Collaboration Technology (ICT) mediated collaboration in relation to geographically separate collaboration facilities and practice. The main objectives have been to identify potential challenges due to the dependency on collaboration technology, increasing the insight into potential vulnerabilities arising in the interface between the operators and the collaboration technology and contributing to insight in potential areas of improvement.

The study is delimited to the views and perspectives of personnel in current onshore positions supporting offshore operations i.e. the research results represent an onshore perspective on the subject of inquiry only. Furthermore, the study focuses on collaboration within drilling operations on the Norwegian Continental Shelf (NCS) limited to routine operations. The research is conducted as an exploratory case study, presenting findings from interviews with industry professionals across 3 major Oil & Gas (O&G) companies on the NCS.

The findings represent information about current concerns and challenges faced by industry professionals in the operational context of Integrated Operations (IO). The interviews revealed a potential for further improvement of the integration between onshore and offshore, in particular within the areas of communication and collaboration.

Based on the findings, potential areas of improvement have been identified. The findings and the exploratory nature of the study identifies several areas for further research.

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CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

The history of oil and gas (O&G) production on the Norwegian Continental Shelf (NCS) dates back to the early 70s and began with the Ekofisk field in 1969. Ever since, the North Sea has been an attractive region, and Norway in particular has been a major supplier of O&G to the world energy market (Liyanage & Langeland, 2009:3480).

The revenue generated by the O&G industry has been crucial for Norway's economic growth, and in funding the Norwegian welfare state. Since production started on the NCS the industry has contributed approx. NOK 11 000 billion to the Norwegian GDP[1], measured in NOK 2013 (Norwegian Petroleum Directorate, 2014:12). However, over the last decades, increasing costs and lower margins have posed a rapidly increasing challenge to the O&G business.

North Sea oil and gas production costs have risen faster than any other industrial sector in the region, causing projects to be shelved and activity postponed, and challenging the long-term viability of existing fields and infrastructure (Oil & Gas Practice: 2014:2). With such dynamics at play, the significance of efficiency in the O&G industry is essential. From its inception the rationale behind implanting Integrated Operations (IO) was based on the belief that this way of organising work will streamline operations and increase effectiveness thus leading to a competitive advantage and increased profits (OLF, 2005).

Today the Norwegian O&G industry is at the forefront in terms of utilising digital infrastructure and Information and Communication Technology (ICT) to improve performance and efficiency within the main activity areas, such as drilling, operation and maintenance (OLF, 2003; Albrechtsen, 2013). Within the O&G industry the term IO refers to work processes that allow for tighter integration of offshore and onshore personnel, as well as operator and service companies. This integration is enabled by ICT and digital infrastructure that allows real-time data sharing between remote locations (Albrechtsen & Besnard, 2010). Several companies on the NCS have implemented IO as a strategic tool to achieve safe, reliable and efficient operations (Steiro & Torgersen, 2013:329). By implementing IO the

[1] Gross Domestic Product

[2] The content presented in the chapter is delimited according to the focus and scope of the research. The

O&G industry aims to increase value through reducing operational costs, accelerating and increasing production and improving Health, Safety and Environmental (HSE) performance (Albrechtsen et al. 2009 in Madsen, Hansson & Danielsen, 2013). These benefits are brought by utilisation of ICT and the subsequent restructuring of organisations.

1.2 OBJECTIVE

Despite the benefits associated with IO, there are emerging concerns that extensive use of ICT may entail hidden problems and vulnerabilities (Liyanage & Bjerkebæk, 2007; Grøtan, 2013; Albrechtsen & Besnard, 2010, Hollnagel, 2013)

This study explores implications of ICT mediated collaboration in relation to geographically separate collaboration facilities and practice. The research objective is to:

- *Identify potential challenges due to dependency on collaboration technology*
- *Increase insight into potential vulnerabilities arising in the interface between onshore personnel and collaboration technology*
- *Contribute to insight on potential areas of improvement based on an onshore perspective*

1.2.1 Scope and delimitations

The study addresses ICT mediated collaboration within drilling operations. A central aspect of drilling operations is that the effort is performed by operator companies, drilling contractors and service companies. A significant number of different actors from a set of different companies interact to various degrees on a limited time span, which in turn results in a complex organising (Tinmannsvik et al. 2011; Bremdal & Korsvold, 2013).

This study is delimited to the views and perspectives of personnel in current onshore positions i.e. the research results represent an onshore perspective on the subject of inquiry only. Furthermore, the study focuses on collaboration within drilling operations on the NCS limited to routine operations.

ICT security and the possibility of misleading, malicious acts and potential consequences of such are not addressed in this study.

Although the risk potential inherent in drilling operations is indisputable (PTIL, 2011) this study does not explicitly address this theme other than a brief reference in section 5.1 Further Research.

1.3 ANALYTICAL APPROACH

To capture the knowledge, experience and perspective of industry professionals the research undertakes an exploratory approach (Yin, 2009; Blaikie, 2010), in which 15 industry professionals across three major O&G companies are interviewed.

This study denotes a socio-technical perspective. Focusing on the interplay between social and technical aspects, sociotechnical theory encourages critical discussion of the relationship between individuals and technology (Coakes & Coakes, 2011).

1.4 STRUCTURE

Chapter 2 presents the conceptual framework[2]; it explains and defines the focus of the research and serves as the basis for studying the subject of inquiry.

Chapter 3 outlines the research design, i.e. it provides a description of all aspects of the research (Yin, 2009).

Chapter 4 presents the research results. The chapter concludes with a discussion of the findings.

Chapter 5 presents the conclusions and possible areas for further research.

[2] The content presented in the chapter is delimited according to the focus and scope of the research. The interested reader may refer to e.g. Albrechtsen (2013) and Grøtan (2013) for a detailed description of Integrated Operations.

2 CONCEPTUAL FRAMEWORK

2.1 SOCIO-TECHNICAL SYSTEMS AND EMERGENT ORGANISATIONAL FORMS

Sociotechnical aspects are recognised by many academics and practitioners as vital to the design and use of work processes in organisations (Coakes & Coakes, 2011; Hollnagel, 2013; Woods & Hollnagel, 2006; Grøtan, 2013; Tveiten, 2013).

Characteristic for socio-technical systems[3] (STS) is that people interact with technology to deliver outcomes; outcomes that cannot be attained by either humans or technology functioning in isolation i.e. the attainment of organisational objectives are met by joint optimisation of technological and social aspects (Trist & Bamforth, 1951). In such systems the conditions for successful performance – and conversely for unsuccessful performance – depend on the interaction between social and technical factors (Hollnagel, 2013:344).

As a result of ICT-based collaboration across geographical boundaries, many forms of collaboration have an increasingly virtual character; the people who collaborate in the organisational endeavour are not necessarily in face-to-face contact. These developments can be classed as new forms of socio-technical systems in which emergent and virtual social systems are dependent upon and mediated by ICT (Eason, 2011).

Sociotechnical thinking is important to the design, development, implementation, and use of information technology systems (ITS). It addresses vital issues in the interplay between social and technical aspects (Coakes & Coakes, 2011). IO promotes a restructuring across the O&G sector which has already created specific organisational structures requiring actors to commit to tasks and responsibilities on a virtual and collaborative basis (Liyanage, 2012). Eason (2011) refers to this as virtual organisations, defined as enterprises in which people engage in

[3] The notion "*socio-technical"* was already used around the mid-twentieth century by researchers from the Travistock Institute of Human Relations in London, in particular by Emery & Trist (1951), as a way of recognising the growing importance of the interaction between humans and technology. The early work was inspired by humanistic values aiming to improve the quality of working life and job satisfaction of employees. This focus on workers was the impetus for conceptualising a socio-technical system as two separate but interconnected systems, a social system and a technical system. The term socio-technical was used to emphasise that both systems are equally important, and that employees are complementary to technology, not subordinated to it (Mumford, 2006).

a collective mission remotely from one another mediated through ICT (Eason, 2011:86). Virtual organisations, in which the technology mediates the interactions in the social system, are an emergent form of socio-technical system (Eason, 2011:85). The emergence of virtual organisations makes distanced and distributed collaboration a growing part of normal work requiring actors to commit to tasks and responsibilities on a distributed collaborative basis (Lyianage, 2012; Ose & Steiro, 2013).

2.2 INTEGRATED OPERATIONS

As pointed out by Albrechtsen (2013) there is no straightforward description of the concept Integrated Operations (IO), as there are different IO solutions among companies and among installations. IO in the O&G industry encompasses various agendas ranging from the deployment of new technology to wide-scale business transformation.

The term "Integrated Operations"[4] refers to "the integration of people, organisations and work processes to improve decision-making and operational performance, enabled by access to real-time data, collaborative technology and expertise across disciplines independent of organisational and geographical barriers" (www.IOcenter.no; Albrechtsen, 2013). The IO concept has become so commonplace that some actors in the industry now claim that they no longer talk about IO - it has become incorporated in the way they work.

Highlighted by Albrechtsen & Besnard (2010) the key elements across companies that apply the concept are broadly the same. Subsuming definitions of the concept from various sources, certain generic properties of IO can be identified:

- Use of information technology and digital infrastructure,
- Increased capture of offshore performance data,
- Use of real-time data to monitor and manage operations across geographical and organisational borders,
- Use of collaborative technology to link different actors in a more efficient and closer way; and

[4] Other terms include: Smart Operations; Real-Time Operations; Smart Fields; e-Field; i-Field; Field of the future; Digital Oilfield; Intelligent Oilfield and Intelligent Energy (Madsen, Hansson & Danielsen, 2013; Albrechtsen).

- Access to expert knowledge

Altogether these properties result in tighter integration of technology, data, competency, activities and organisations (Albrechtsen & Besnard, 2010) serving to increase the connectivity and interactivity between offshore O&G assets and their onshore support systems (Liyanage & Langeland, 2009:3481).

Lilleng & Sagatun (in Albrechtsen, 2013:15) compile IO conditions (elements) in a stack model[5]. The idea of a stack is that all levels in the model need to be in place to enable value creation. The model may serve to better understand the inherent complexity of the totality, seeking to decouple the complexity of the system by introducing distinct layered activities connected by standard interfaces. The model assumes an ordering or hierarchy (Henderson, Hepsø & Mydland, 2013). The fundamentals for successful value creation by means of IO are illustrated in figure 1.

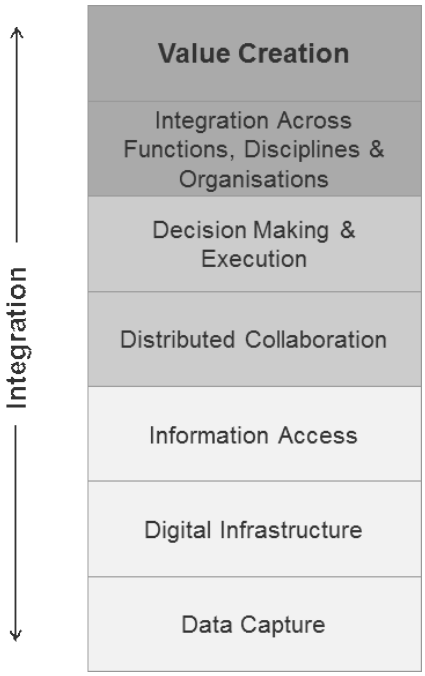

***Figure 1**: IO Elements (Inspired by Lilleng & Sagatun, 2010 in Albrechtsen, 2013:15).*

[5] A stack model is a layered representation of a complex system (Henderson, Hepsø & Mydland, 2013:8).

The figure illustrates that the levels are interlinked and interdependent, emphasising the importance of integration (Albrechtsen, 2013). For example, elements at lower levels i.e. data capture, digital infrastructure and information access are required to enable execution at higher levels such as e.g. distributed collaboration.

2.3 THE TRANSFORMATIVE ROLE OF ICT

A significant aspect of IO is that it re-engineers the industry infrastructure that supports the activities in offshore assets (Albrechtsen, 2013; Liyanage et al. 2006:388). The digital infrastructure provides an organisational setting capable of (Albrechtsen, 2013:13; Liyanage et al. 2007; Liyanage & Langeland, 2009):

- 24/7 network-based connectivity;
- Real-time monitoring;
- Capture, visualisation and transfer of real time data;
- Integration and standardisation of applications, including integration of ICT systems and process control systems;
- Dispersed collaborative arenas; and
- Automation and instrumentation of work processes

This development facilitates collaboration among the O&G producers, service contractors, and support & supply organisations (Liyanage et al. 2006; OLF, 2003; Grøtan, 2013; Albrechtsen, 2013). The adoption of IO spurs substantial changes in work patterns on the NCS, as well as in the onshore support services (Albrechtsen, 2013).

2.3.1 From Conventional Practice to Integrated Approaches

ICT has become a key enabler of the concept's transformative aims. The digital infrastructure is a prerequisite for effective collaboration and information sharing across locations: it unites discipline experts independent of geographical location that allows online real-time connectivity with the offshore control rooms, offshore equipment and activities (Liyanage et al. 2006; Liyanage & Bjerkebæk, 2007).

Figure 2 illustrates prominent transformative effects of ICT applied in IO compared to conventional practice. Implementing IO implies that the conventional practice is substituted by more integrated approaches (Ringstad & Andersen, 2006 in Skjerve et al. 2013).

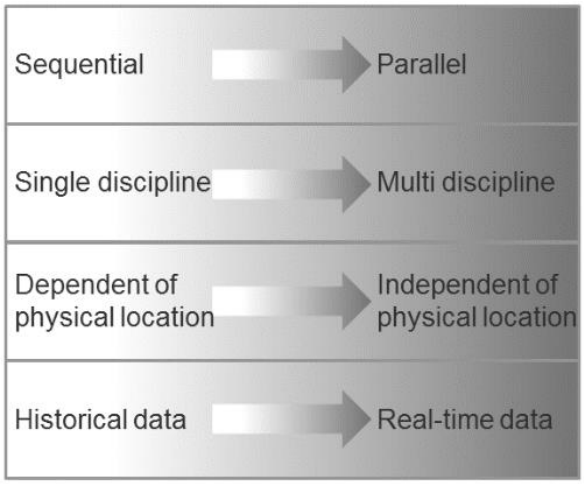

***Figure 2**: Changes in work practices – from conventional practice to Integrated Operations (Moltu, 2013:142).*

IO work processes represent a parallel way of collaborating contrasting with the traditional sequential way of work execution (OLF, 2005). This enables multidisciplinary professionals to analyse real-time data in collaboration, thus making decisions and taking corrective actions to optimise operations. In addition, such collaboration is location independent as technology allows for assembling people with the necessary competencies onshore (Rosendahl & Egir, 2008; OLF, 2005).

2.3.2 Distributed Collaboration

IO implies an increased use of distributed teams i.e. teams composed of individuals with complementary skills and knowledge, located on- and offshore (Albrechtsen, 2013). Decision making will increasingly be executed by distributed teams (Kaarstad et al. 2009 in Rindahl et al. 2013).

Effective means of virtual communication and collaboration between on- and offshore become crucial as employees are moved onshore (Liyanage, 2012). Virtuality can be defined as activities between parties on different geographical locations. Accordingly, a virtual organisation consists of people working towards a shared goal across space, time and

organisational boundaries made possible by communication technologies (Gulbrandsøy et al. 2004). Compared to conventional practice, IO implies greater reliance on advanced application technology and digital capability, resulting in increased interaction and collaboration and increased information exchange across organisational and geographical boundaries (Liyanage et al. 2006).

Multidisciplinary team work is enabled by the availability of real-time data. Real-time data at distributed locations enable personnel to collaborate based on a shared and up to date description of the operational status. Expert knowledge becomes more readily available as a result of the collaborative environment. (Moltu, 2013).

By utilising real-time data, onshore support, shared information and expert knowledge it is claimed that decisions and decision making processes will improve and provide "better, faster and safer" decisions (Albrechtsen et al. 2009 in Madsen, Hansson & Danielsen, 2013:42). Onshore monitoring of offshore performance data enables improved decision-making support and the capability to adapt to unexpected events as the capability to detect anomalies and trends improves (Albrechtsen & Weltzien, 2013:359). Figure 3 illustrates how access to and sharing of real-time data connects various actors and enables real-time monitoring of offshore operations

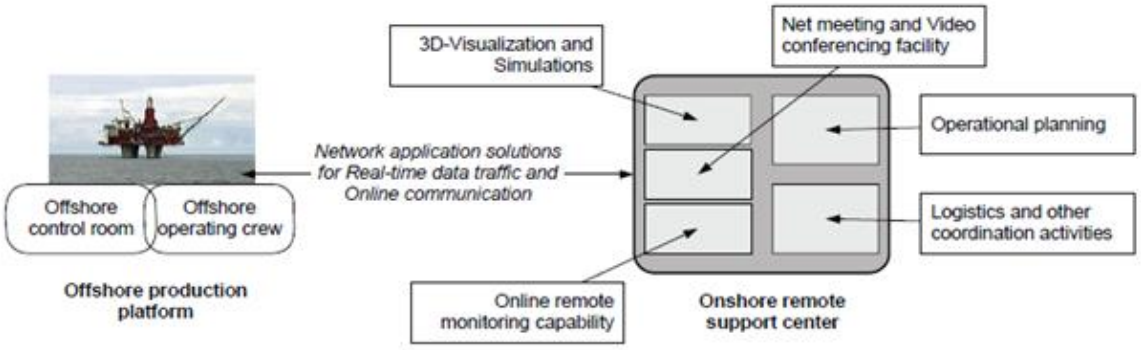

***Figure 3**: Operational context based on advanced technological capability and digital infrastructure (Liyanage & Herbert, 2008). An illustrative example.*

Real-time data mirrors the drilling process and provides information on key parameters to the Onshore Operation Centre (OOC) and to onshore remote support centres. The real-time data is shared between offshore and onshore, in which operators and vendors process, analyse and visualize the data. This enables safer and more efficient drilling operations involving real-time supervision of the drilling process and early detection of abnormalities and diagnosing of upcoming problems and issues (Albrechtsen, 2013).

2.3.3 Onshore Operations Centre

IO involves transfer of responsibilities and tasks to onshore, thereby providing the land-based support services with an increased significance for the operational activities on the NCS (Grøtan & Albrechtsen, 2008; Albrechtsen, 2013).

A key aspect of IO is the establishment of Onshore Operation Centres (OOC) which has enabled companies to move tasks from offshore to onshore (Gulbrandsøy et al. 2004). An OOC is a centre supporting the offshore operations, and is especially designed for effective communication and collaboration between onshore and offshore assets, consisting of various discipline experts (Grøtan & Albrechtsen, 2008).

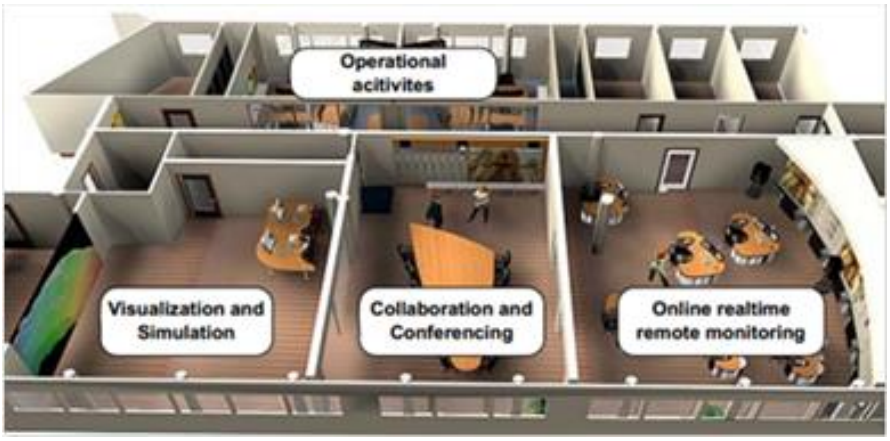

Figure 4: *Onshore Operation Centre (OOC). (Liyanage et al. 2007:396). An illustrative example.*

Collaboration rooms are instrumental in realising the technological capabilities as they facilitate collaboration by providing video conferencing, sharing of large data sets and remote control and monitoring (Rosendahl & Egir, 2008). These centres are equipped with key

technologies and discipline competencies to provide both routine and critical support to offshore operations[6] (Liyanage & Herbert, 2008; Albrechtsen, 2013). Experts from different disciplines can collaborate more closely which facilitates more rapid response and decision making (Rosendahl & Egir, 2008). Examples of technologies available to support collaboration across distance are shared workspaces, data sharing facilities, video-conferencing facilities, CCTV[7] and software tools[8] (Liyanage & Langeland, 2009; Moltu, 2013).The shared workspaces provide access to broad repertoires of knowledge, resources and expertise that support both routine and critical situations (Albrechtsen, 2013).

[6] Note: The offshore installation manager (OIM) still remains responsible for the offshore operations, (Albrechtsen, 2013:18).

[7] Closed-circuit television.

[8] This relates to both OOC's and offshore control rooms.

3 RESEARCH DESIGN

3.1 QUALITATIVE CASE STUDY RESEARCH

As previously stated, the main objective of this study is to explore implications of ICT mediated collaboration in relation to geographically separate collaborative facilities.

Qualitative case studies[9] excel at bringing an in-depth understanding of complex issues, and may extend experience or add strength to what is already known through previous research (Yin, 2009). Proponents of qualitative case study research assert that the approach is eminently justifiable if the objective is to *"attain an in-depth understanding of a contemporary phenomenon in a particular context"* (Farquhar, 2012; Yin, 2009; Creswell, 2013). Thus, qualitative case study research permits a situational approach, and may contribute to producing an insightful understanding of the subject of inquiry (Farquhar, 2012; Yin, 2009).

Qualitative case studies have traditionally been viewed as lacking rigour and objectivity when compared with other research methods. Notwithstanding this criticism, the approach is widely used due to its advantages in creating novel and profound insight which may not be achieved with quantitative approaches i.e. aggregated statistical research (Yin, 2009). While proponents of the approach agree that there are shortcomings in the methodology of case study research, they contend that these shortcomings are not innate, and thus represent opportunities for development within the design and execution of the research (Yin, 2009; Creswell, 2013; Farquhar, 2012).

[9] There are various definitions of what constitutes case study research in the literature of social sciences (Yin, 2009; Farquhar, 2012; Creswell, 2013). It should be noted that for the current study the term *case* refers to the unit(s) of analysis, while the term *case study* refers to the overall research design (Yin, 2009; Creswell, 2013). Furthermore, literature on case study research is presented only as far as it is relevant for the current research. Given this purpose and the scope of the current study, this brief description does not serve as an in-depth introduction to case study research. For an extensive review of case study research, reference should be made to contemporary literature (e.g. Yin, 2009; Farquhar, 2012; Creswell, 2013; Zikmund et al. 2013).

3.2 DATA COLLECTION

The exploratory nature of the study requires collection of primary data (Gripsrud et al. 2004), i.e. information obtained specifically for the current study, in which the overall aim is to produce a description of the subject of inquiry based on, and consistent with, the perspectives, knowledge and experience of industry professionals.

3.2.1 Interviewees

15 industry professionals across three operator companies were interviewed, representing the largest O&G companies on the NCS. The companies exhibit similar characteristics pertaining to the implementation of current IO-solutions.

The interviewees were interviewed on the basis of having particular insight into the subject of inquiry[10]. To ensure sufficient breadth and depth the interviews included both operative and non-operative representatives.

The operative interviewees represent the onshore part of the drilling organisation, i.e. various discipline experts providing support to offshore drilling activities. Service companies are also represented in this group of respondents. The non-operative interviewees possess extensive knowledge in areas essential to IO but do not support the offshore drilling operations on a daily basis.

Personnel currently holding offshore positions were not represented. However, it should be noted that the majority of both the operative and non-operative interviewees have previous offshore experience.

The duration of each interview was approximately 2 hours. A list of the interviewees is presented in the table below:

[10] In the literature of social sciences this is referred to as *purposive selection* (Creswell, 2013).

Company	Role	Operative	Non-Operative
A	IO-Advisor		x
	OOC Coordinator	x	
	Manager IO Development		x
	Drilling Engineer	x	
B	Senior Consultant		x
	IO-Advisor		x
	Superintendent D&W	x	
	Superintendent D&W	x	
	Superintendent	x	
C	Senior Consultant		x
	Drilling Supervisor	x	
	Drilling Engineer	x	
	Drilling Optimization Engineer	x	
	Drilling Engineer	x	
	Drilling Optimization Engineer	x	

***Table 1**: List of Interviewees*

3.2.2 Interviews

The interviews were conducted as "semi-structured"[11], a widely used technique in qualitative research as it provides the interviewer with an opportunity to pursue in-depth information (Blaikie, 2010). Unlike formal or structured interviews which follow a rigid format of set questions which does not allow one to divert, semi-structured interviews focus on specific themes, covering them in a conversational style (Creswell, 2013). This form of interviewing is particularly conducive to exploratory research as it may provide information not anticipated by the interviewer (Zikmund et al. 2013; Farquhar, 2013).

A widely embraced advantage of semi-structured interviews is their flexibility. The flexible format permits open-ended questions, i.e. questions posed to encourage a complete, meaningful answer based on the interviewees' knowledge and experience. As a result, it has the advantage of allowing both the interviewer and the interviewee flexibility to probe for details and to generate discussion regarding the subject of inquiry (Creswell, 2013; Farquhar, 2012).

[11] Semi-structured interviews are also commonly referred to as "in-depth" interviews (Creswell, 2013).

The interviews were conducted based on a framework of themes to be explored; hence they were based on an interview guide i.e. a set of pre-planned core themes for guidance so that the same topics were covered with each interviewee (Appendix 1). The interviews were not pre-fixed in structure, but allowed for flexibility and contextual adaption (Farquhar, 2012). The main themes, including a number of sub-themes, were:

- General on IO implementation
- ICT-based collaboration
- Digital infrastructure
- Collaboration between onshore and offshore
- Acquisition and processing of real-time data

The interview guide was revised by incorporating tentative findings, i.e. new topics were included as they were highlighted by the interviewees. Hence, the interviewees themselves highlighted additional issues, and these form an integral part of the study's findings. This ability to adjust the data acquisition as a result of insights obtained during the research process is one of the key advantages permitted by the qualitative case study approach (Farquhar, 2012).

3.3 DATA ANALYSIS

The analysis draws on features of Yin's (2009) model of multiple-case design. The analysis was executed by employing two levels of analysis: (a) *within-case analysis* and (b) *cross-case analysis.*

Within-case analysis refers to the in-depth exploration of the information provided by each of the three companies as a stand-alone entity. This implies that each company is considered a single case (Yin, 2009) and the process entailed sifting through all the data and extracting the data most salient to the subject of inquiry, the purpose of which was to identify and describe aspects of the subject of inquiry. The underlying logic of this level of analysis is inductive, placing emphasis on allowing any relevant information on the subject of inquiry to surface (Blaikie, 2010). Hence, this level of analysis proved useful in identifying the unique characteristics of each site.

The analysis of multiple cases based on qualitative data, in particular transcripts of interviews, inevitably involves the handling of large quantities of data. Categorising the data permits reduction of large quantities of data into a format that fosters a reliable and credible analysis, as it preserves the essential content while at the same time creating a manageable volume which still reflects the original material (Farquhar, 2012). The data from each site was recorded following the same format, i.e. the transcripts of each individual account were categorised into structured schemes, expressing the main statements made by each interviewee, which were those phrases, sentences or paragraphs that related directly to the subject of inquiry.

The categorised set of data subsequently facilitated the next level of analysis i.e. cross-case analysis (Yin, 2009; Farquhar, 2012). Cross-case analysis entails analysing the cases comparatively in order to identify similarities and differences. Hence, it facilitates comparison of the subject of inquiry across the researched sites. This level of analysis extends the understanding of the subject of inquiry beyond the single cases, facilitating a single set of cross-case conclusions (Yin, 2009).

3.4 RELIABILITY AND VALIDITY

To facilitate the assessment of methodological rigour[12] of the conducted research, explicit attention to reliability and validity is a prerequisite (Farquhar, 2012). However, due to the subjective nature of qualitative data, the issue of adequate validity and reliability is a major criticism of qualitative research. Nevertheless, a variety of methods of assessment exist (Yin, 2009; Blaikie, 2010; Farquhar, 2012; Creswell, 2013).

3.4.1 Reliability

The design of the current research shares some features with Yin's (2009) model of multiple-case study, notably in the treatment of each case as separate entities to permit replication - that is, using multiple cases to independently confirm emerging themes. The rationale behind replication logic is that if the same findings are established across somewhat independent

[12] Rigour can roughly be understood as meticulousness or precision (Farquhar, 2012:100).

cases, it leads to more generalizable findings. Hence, findings that appear across multiple cases acquire greater robustness (Yin, 2009; Farquhar, 2013).

Although semi-structured interviews allow for replication of the interview, the open-ended and flexible format implies that replication is less controlled than e.g. quantitative surveys, and thus more difficult to replicate (Yin, 2009; Farquhar, 2012). The interview guide however, consisting of a set of guiding themes, served the purpose to ensure a degree of consistency and comparability. The analysis revealed regularities i.e. recurrent themes across the researched sites; hence the issues expressed by the interviewees were congruent to a great extent.

Each interview was tape-recorded and transcribed to secure an accurate version of the information, i.e. to ensure reliability. Furthermore, quotes are cited in the presentation of the research results. The use of quotes thus constitutes a fundamental foundation for ensuring reliability (Creswell, 2013; Bloor & Wood, 2006).

3.4.2 Validity

The complexity of the empirical data implies that the data is open to different interpretations and potential "researcher bias" (Blaikie, 2010). Bias refers to any influence that distorts the results, and may derive either from a conscious or unconscious tendency on behalf of the researcher to collect data or interpret the data in such way as to produce erroneous conclusions. Hence, it implies deviation from the "truth" either as a consequence of limitations of the research design or from the data analysis (Bloor & Wood, 2006:21). Thus bias is associated with validity, that is: to which extent the research produces an accurate version of the researched sites, i.e. the degree to which the researcher's conclusions correctly portray the data collected (Bloor & Wood, 2006). For example, within interview-based research, as with the current study, bias may occur as a consequence of particular questions being asked during the interview or in the way in which questions are being posed (Bloor & Wood, 2006:22). However, as the flexible format of semi-structured interviews permits open-ended questions, i.e. questions encouraging a full answer based on the interviewees' knowledge and experience it was desirable to let information emerge from the field. The interviewees were therefore allowed the opportunity to express their perspectives and thoughts on the subject of inquiry as freely as possible. Hence, potential bias was sought

mitigated by avoiding posing leading questions, which subtly prompt the interviewee to answer in a particular way, i.e. such questions were avoided as they may result in incorrect or slanted information (Bloor & Wood, 2006). Questions of sensitive character were also avoided, i.e. the questions targeted the characteristics of Integrated Operations rather than e.g. the specific role and competence of the individual interviewee.

Furthermore, to promote validity, validation took place throughout the data collection process by checking whether preliminary findings were a subject in subsequent interviews (Farquhar, 2012). Preliminary findings were also presented at the end of the interviews, allowing the interviewee the opportunity to comment.

In terms of analysis, researchers may be vulnerable to bias due to being vigilant in searching for data that support e.g. a favoured theory or a conceptual framework (Bloor & Wood, 2006:2). As for the current study the conceptual framework was developed to accommodate and illuminate the empirical data. The conceptual framework was constructed alongside the growing volume of data. Hence, collecting and analysing data represented an iterative process by which the collection of data influenced the design features of the conceptual framework (Yin, 2009; Farquhar, 2012). Thus, potential bias was sought mitigated by revising and modifying the conceptual framework in light of the data.

Qualitative case study research is particularly subject to criticism on the grounds of non-representativeness and a lack of external validity. External validity which is also commonly referred to as "transferability" or "generalizability" refers to the extent to which the researcher's conclusions still hold true beyond the immediate cases (Bloor & Wood, 2006; Blaikie, 2010). Hence, research which is generalizable enables the results to be brought into a more general use (Bloor & Wood, 2006:93).

As for the current study the degree of generalizability or external validity is enhanced by emphasising transparency, i.e. ensuring that the research report is sufficiently detailed for the reader to be able to question and examine the study. Potential similarities and differences can then be taken into account in any judgement about the relevance of findings (Blaikie, 2010; Creswell, 2013). Thus, the final decision regarding the "generalizability" of the research is ultimately in the hands of the reader, not the researcher (Farquhar, 2012; Creswell, 2013). The reader of the research report determines the degree of congruence between the context in which the research is conducted and the one to which the findings may be transferred. This

however implies that the reader must have adequate knowledge of the researched context i.e. IO, and particularly drilling operations, to determine whether there are sufficient relevant similarities that make it plausible that the conclusions should also hold beyond the researched sites.

3.5 PRACTICAL IMPLICATIONS

The conceptual framework, i.e. chapter 2, serves an instrumental purpose in illuminating the findings, and subsequently it has implications for the conclusions that may be drawn.

The conceptual framework primarily draws upon existent works in the field of IO in order to accommodate and support the empirical data. The socio-technical perspective has still been prevalent. Consequently, the research is based on a very broad foundation to illuminate the subject of inquiry. This option can be criticised for being too superficial. However, delimiting or restricting the research to one or few specific theoretical perspectives was deemed conflicting with respect to the exploratory approach.

Furthermore, the research results do not highlight contextual variations across the three researched sites, but rather describe those aspects pertaining to the subject of inquiry that are common to all sites. Thus, the individual case reports are not presented as part of the research results, implying loss of some of the original context from each site. However, the individual case reports serve as the evidentiary base and are cited in the presentation of the results.

3.6 LIMITATIONS

The results are based on the responses of 15 interviewees. This implies that the empirical base is limited and this inhibits the ability to make definitive conclusions about the findings i.e. the findings should not be treated as generalised facts.

Moreover, the collection of empirical data is limited to personnel in current onshore positions. Readers should keep in mind that the results represent an onshore perspective only; reference to an offshore setting would most likely produce altered results due to the contextual differences between onshore and offshore. Readers are advised to assess the results in light of the study's limitations.

3.7 ETHICAL CONSIDERATIONS

The interviewees received information regarding the study by e-mail prior to the interview, aiming to ensure that the research was conducted according to acceptable standards of practice (Appendix 2 and 3). The email stated the nature and purpose of the research, the methods that were to be used, what would be required of the interviewee, and how the results would be presented. It was further emphasised that the interviewees' privacy and the participating companies' information would be protected by preserving anonymity.

4 FINDINGS AND DICUSSION

The findings are based on an overall analysis of information provided by the interviewees, and include direct quotations.[13] The chapter concludes with a discussion of the findings.

Despite the challenges and concerns expressed by the interviewees it should be noted that they emphasised that there has been substantial improvement as a result of the implementation of IO. The quotes below recapitulate frequent statements, in particular with respect to improved collaboration, learning opportunities and knowledge sharing.

"It was pretty clear once we did this - moved people onshore and sort of collected people together - that it actually was a better way of working. You improved how people communicated; you improved the opportunity for support. You also, as it developed, realised that this is a really good opportunity for learning and competence building"

"We certainly have seen some value in IO. A lot of things have improved. For instance, the collaborative environment enables us to better utilise the best of competence within the organisation and those external to the organisation"

"We have improved the learning environment as expertise from various disciplines is brought together on a day to day basis - and that's a really good way of transferring knowledge"

However, the findings below illustrate a potential for further improvement of the integration between onshore and offshore; service companies involved in the operation, various disciplines and functions in the operating company, in particular within the areas of communication and collaboration.

4.1 FINDINGS

The issues and concerns expressed by the operative and non-operative interviewees were congruent to a great extent. However, the operative interviewees highlighted some issues not expressed by the non-operative interviewees, namely;

[13] Some quotes are translated from Norwegian to English and in some of the quotes details are omitted to ensure confidentiality; however the significance is preserved.

- Need for translation due to language barriers
- Challenges regarding follow-up of several operations simultaneously

4.1.1 Offshore Experience and Knowledge

Due to distance to the operations, several of the interviewees expressed concerns that the IO work practice potentially could lead to lower performance due to lack of understanding and knowledge of the offshore installations. In relation to this, several of the interviewees highlighted that many of the individuals in the OOC have never been offshore and consequently are not familiar with the offshore environment.

"They have no local understanding.[14] They should have had offshore experience to work here. Clearly it's an advantage with offshore experience. It's much easier to discuss with them then"

Furthermore, it was also stated that onshore personnel experience a complex work situation and find it challenging to follow up multiple operations on different rigs with different equipment, procedures and processes simultaneously. This was emphasised as particularly challenging in relation to personnel without offshore experience.

"It's much more to keep track of, many more issues, much more equipment so it can definitely be challenging. It is obvious, the more operations - the more hectic. It can clearly be safety critical at times. We work towards many rigs with different equipment and systems"

4.1.2 Language and Intercultural Issues

The fact that people from various countries work together in the OOCs was mentioned as a potential source for misunderstandings.

"Officially the working language is English, but Norwegian is most commonly used offshore. We have people from all over the world in the onshore centre. It's a multi-cultural environment"

[14] "Local understanding" refers to installation specific knowledge.

"The morning meetings are often in Norwegian. The unions require Norwegian to be spoken which is challenging for non-Norwegians. That is a source for misunderstanding"

As most of the communication with offshore assets is in Norwegian, the foreign employees have to get e.g. radio communication translated by a Norwegian colleague. Often discussions on operations or necessary actions are in Norwegian, and translation is therefore required. This was highlighted as a potential source for misunderstanding which in some cases also leads to lower efficiency.

"It is easier to work here if you are Norwegian because the communication takes place in Norwegian. Most drilling crews are Norwegian. If you don't understand Norwegian you miss information provided via radio. I know that this sometimes creates irritation offshore, resulting in less contact with the OOC. Language is a key factor, it is not easy to keep track if you do not understand what is being said"

"My colleague is from (...) and he doesn't understand Norwegian, and we sit here and listen via the radio. I have to translate what's going on and what actions we are going to take, what we are going to do. That can be a bit troublesome when it's hectic"

Furthermore, in an increasingly international O&G industry with many different nationalities working together in the same operations, cultural differences were highlighted as a potential challenge. This may become particularly prominent in situations where personnel in the OCC ask for advice from global specialist centres located in other countries.

"External support located in other countries has increased in recent years and creates challenges in terms of communication and culture"

"We have people from all over the world working in the centre, so it's sort of a multilingual, multicultural environment. So you have to realise how important people's culture is when you communicate, for example like the way certain cultures don't want to lose face, they don't want to say no, even though they know things aren't right. So you have to think about things like that"

4.1.3 Collegial Involvement and Trust

Several of the interviewees expressed concerns regarding the fact that they do not know the offshore crews. Some stated that the lack of collegial relations in some cases results in insufficient communication and collaboration between onshore and offshore.

"It's a challenge when people do not know each other - we have never met face to face"

"A complicating factor is uncertainty due to lack of personal relations – people are different, people have different personalities, for example some are extrovert while others might be introvert. It was much easier when I worked offshore and knew my colleagues. Now I don't know the people I communicate with. The uncertainty that comes with not knowing things like that is an issue"

"Loss of personal relations - things were much easier before. It's an advantage to know those you work closely with"

In relation to this, it was also stated that the level of trust between on- and offshore varies.

"Trust is an issue due to the fact that you are not on the rig and talk to people face to face"

"Offshore needs to trust the decisions and models you have made in here"

The onshore teams are actively involved in problem-solving and decision-making related to the offshore operations. In relation to this it was stated that some offshore crews have barriers with respect to involving the OOC.

"Sometimes offshore does not sufficiently involve onshore"

"This varies from crew to crew. Sometimes you have crews involving the OOC less. Why are some keen to give us information, while others are not? That is an issue"

Lack of trust was highlighted as an explanation as to why offshore personnel does not involve the OOC.

"You have a crew that is out there that doesn't know what these people are doing onshore. They don't know what's going on, they have no relation, and they do not feel like one of us. It takes time to establish trust"

"We see that quite often really, crews that don't involve the operation centre sufficiently"

Some interviewees expressed that the onshore personnel sometimes notice that offshore colleagues tend to mistrust their support and advice. Furthermore, it was stated that senior offshore workers in some cases mistrust their onshore colleagues due to their perceived inadequate offshore experience and their lacking ability to understand the working conditions offshore.

"The older generation tend to distrust some of the information from onshore. Do you experience this frequently? Yes, quite often, but particularly in the beginning when I was new"

4.1.4 Distributed Decision-Making

Ensuring involvement and a common situational awareness between distributed teams is instrumental. Some of the interviewees expressed that they sometimes experience this as rather challenging due to the fact that there are many contributors and disciplines involved and consequently many views and opinions.

"Something that is challenging with IO is decision-making in distributed teams. How do you ensure involvement? How do you ensure comprehension? How do you ensure common situational awareness?"

"When you involve onshore, then there's a lot more people involved in the decision-making process - then it gets a bit more complicated"

"There's still a lot of potential here in the area of collaboration and communication and situational awareness for example. I still think we've got a long way to go there"

In relation to the above some interviewees expressed concerns about the potential for erroneous decisions. A related concern is that it might be difficult for everyone to know when decisions have actually been made.

"If people are holding different understandings when making joint decisions it is rather hazardous. It's challenging when you are located at different locations. How do we ensure that everyone has the same basis for the decisions to be made? And how do you get it

distributed and communicated so that everybody knows which decision has been made and on which basis"

4.1.5 Digital Infrastructure

Sufficient transfer of data through an optimal infrastructure was emphasised by the interviewees as crucial for successful operations. The onshore personnel work towards several rigs with different equipment and systems as well as with various external providers and thus have to relate to many systems and software applications. Some of the interviewees stated that they sometimes experience it as challenging to gain the necessary knowledge on how to handle this complexity. Standardisation was mentioned as a need and crucial to ensuring efficiency and better flow of information. Furthermore, it was expressed that applications and systems constantly are under development and change.

"Some systems are difficult to understand, very bureaucratic or very complicated, it's not very intuitive. It's difficult for people."

"It is a challenge. We have more and more data and more and more applications, and more to keep track of. Sometimes you get the feeling that there is too much information. It is a challenge to keep track of everything that happens"

"The fact that we get more and more data programmes and more and more software databases, the chance for something going wrong somewhere increases"

"There are challenges related to the various programmes, to communicate with each other, from programme to programme and from database to database"

Also, some of the interviewees stated that they sometimes experience that their IT-skills are insufficient.

"We need to be better at using the systems. There is no lack of systems; it is more a lack of knowledge on how to use the systems"

"The roles of people have changed quite a lot over the years because the people that are working for example in the drilling centre need a lot more competence about networking, a lot more IT-skills than just running an application or running something offshore, and how

we move data and information around for example, how do we remotely operate computers and things like that"

Furthermore, as a consequence of the many involved contributors and lack of standardisation of systems it was mentioned that IT-security, IT systems accessibility and -stability sometimes becomes a barrier for communication and efficiency. It was stated that getting access to systems in some cases is too time consuming.

"Access to our IT-system - that's a challenge as well"

"Firewalls and stuff - all these things are there to protect us - some of that - at the moment is not really enabling - in fact that's stopping the communication or making it more difficult. So we're looking at – how can we still have the same level of security but have a better way of communicating and sharing and all that"

"The more secure you want it to be, the harder it is to make it accessible. Availability and security is sort of contradictory. That is clearly an issue"

Technical problems like computer crashes, programme failures, necessary restarts and poor data links between on- and offshore were listed as potential serious challenges for safe and efficient operation.

"We often experience computer crashes, programme failure, necessary restarts and problems with the data link between onshore and offshore"

"However, if the communication was cut, it would be difficult. Today with such inexperienced drilling people who are on the rigs, they had not managed so well without the system we have today"

"There are challenges in relation to different types of networks between companies. At times it's complicated to get access"

"Sometimes things go wrong resulting in the operator not getting the data they should have had"

Also, sufficient quality of communication channels was mentioned as a problem. The quality from the offshore video feed in some cases is poor.

"A blurry picture and long distance to the camera make it difficult to see the body language and who is talking"

The interviewees highlighted that poor data quality often is an issue and emphasised the importance of correct data input. Another concern is that too much time is spent on interpretations and models to get the "bigger picture", and consequently posing challenges with respect to maintaining a full overview of the current situation.

"Because of data quality issues you might have the situation where you get two versions of one model - one is different to the other, and you wonder about which one is correct."

"Data quality is an issue. You can produce two different realities based on the same data when you use two different models. You have the potential to make decisions on different grounds"

"Sometimes we discover that the data are so uncertain that we cannot use it. The input is of low quality"

In relation to this it was also stated that the interpretation of real time data is often experienced as too complex. Delays in processes and decision of actions to be made are mentioned as result of spending too much time on understanding the "big picture".

"It is sometimes very difficult for a person to understand exactly what's going on, it's too complex"

"How we use that data is sometimes a struggle. We are working really hard on data quality"

"The danger is if you spend too much time on the models to get the big picture, and then forget what happens - it can be a problem"

Several of the interviewees expressed capture and application of real-time data as areas in need of improvement.

"When it comes to using real-time data I think that we still are not good enough. This data only has a value when placed in context, there are many things going on so it's very important to be able to visualise and share this data to produce a common situational awareness - it's an area where we have lots of challenges"

Concerns were also expressed about the increasing complexity that comes with technology dependence and that there is a potential risk of not understanding the interactions and any gaps that might occur.

"We do get the challenge that we must deal with increasing complexity in our operations. The risk might be that we do not understand the interactions and any gaps that might occur"

"I see it as a risk factor that we do not see the complexity. This is so complex that we might not see the dependencies and consequences of what is happening"

4.1.6 Information Overload and IT Issues

The interviewees stated that the IO concept provides extensive amounts of information often causing the onshore personnel to be overloaded with data and different applications. They expressed that they have to relate to an overwhelming load of information and that it might be a challenge to extract and assess the relevant information efficiently. A concern is that this might be a problem in a potentially hazardous situation.

"If you have a lot of information it is sometimes very difficult for a person to understand exactly what's going on, it's too complex"

"There are huge volumes of data to manage, large plots to manage. At times you monitor several rigs and wells simultaneously - in practice this might be difficult. One can mix things up and lose track"

The interviewees expressed that they face challenges related to acquisition and processing of real-time data. In an environment with an overwhelming load of information, it may be hard to extract the relevant data. Visualisation and sharing of data may therefore be perceived as challenging. Insufficient transfer of necessary data due to a failure of e.g. digital infrastructure and differences in how data is represented between personnel from different disciplines represent a challenge. Furthermore it was stated that uncertain and inconsistent data leads to delays and potentially different views on situational understanding. Sometimes they also experience getting different versions of models

Additionally, several interviewees expressed that it is a challenge to find the relevant information at the right time, and subsequently that efficiency and correct basis for actions and decisions may suffer.

"There is too much information; sometimes it's difficult to find information on time"

"Often we're overwhelmed with information. The information to solve a problem is out there somewhere, but sometimes you can't find it"

In relation to this it was also stated that rapid development and changes of various systems and programmes is a potential challenge.

"The capacity of the systems just keeps growing. We need systems which extract the information that is significant to us. This is a challenge."

Another factor that was mentioned was the potential loss of overview because of sectioning of information due to many involved contributors and poor system integration.

"In the context of IO where we have complex operations involving many contributors we might get examples of sectioning of information"

"There is clearly room for improvement, for sure, that someone knows something and someone else knows something else"

4.2 DISCUSSION

As highlighted in the conceptual framework, digital networks; real-time data exchange; information systems etc. – all prerequisites for IO – have resulted in organisational forms that are highly dependent on technology and information solutions (Liyanage & Bjerkebæk, 2008).

Notwithstanding the progress expressed by the interviewees as outcome of the implementation of IO, the findings clearly indicate that the concept is subject to various challenges and hence further improvement opportunities. As described in more detail below, the main concerns were related to lack of offshore experience and knowledge, language and

cultural issues, collegial involvement and trust, distributed decision making, digital infrastructure, information overload and IT issues.

In the following, the findings will be discussed in accordance to the stated research objectives.

4.2.1 Challenges due to dependency on collaboration technology

Drilling Operations increasingly rely on information systems which make ICT-related factors important as enablers or hindrances of efficiency as well as safe operations. Moreover, drilling operations depend heavily on well-defined information and knowledge bases to retain necessary levels of integrity (Liyanage & Bjerkebæk, 2007). The findings illustrate how collaboration technology has the potential to alter the effectiveness of information exchange.

The movement towards IO is creating forms of sociotechnical systems different from those characterising conventional practice. Technology takes on a pivotal role as the mediator of communications and collaboration in a social system where members often only know one another through the technology. The research identifies several challenges, e.g. issues related to digital infrastructure, insufficient knowledge of constantly changing systems. Information overload and other IT-issues pertaining to access, firewalls etc. equally represent a challenge.

The findings indicate that challenges related to the dependency on collaboration technology can be divided into two main categories; *Challenges related to the effectiveness and efficiency of the digital infrastructure*, i.e. hardware and software related aspects and *Information Overload and IT Issues*, i.e. the very amount of data and information at hand and the operator's ability to process and understand the significance of the information flow and ultimately, the degree to which they are able to keep necessary focus on the information most relevant for their tasks.

During the research it became apparent that individuals struggle with understanding how to prioritise and sort the relevant data from the less important information. This is attributed to the lack of standards and a high pace in systems and software upgrades. Insufficient IT knowledge is also frequently mentioned as a factor along with insufficient image quality from the video feed.

Although obvious, an important finding is that systems stability poses a challenge when not satisfactory. Technical problems were listed as potential serious challenges for safe and efficient operation. An important reflection made by interviewees was that the consequences of system down-time are aggravated by the fact that the offshore drilling crews are often inexperienced and hence, heavily reliant on the communication systems for necessary support from the onshore team.

The findings strongly suggest that successful implementation of Integrated Operations is dependent on solid understanding of the limitations in the socio-technical interface. Systems design, user interface and organisational structures should be subject to close attention in order to mitigate the challenges identified to the degree possible. Bearing in mind that IO is a field characterised by a high degree of interdependencies, unilateral focus on technology or organisation as separate entities inevitably entails a risk for sub-optimisation. A robust and user friendly ICT system is a prerequisite but equally important is a well adapted organisation focusing on trust, sound collegial relations and efficient communication and role clarity.

4.2.2 Vulnerabilities arising in the interface between onshore personnel and collaboration technology

IO requires the integration of advanced technology supported by an organisational structure that allows for the delivery of excellent operational and business performance. In this context it may be relevant to reflect on Eason's (2011:93) relevant paradox: "How are these processes that seem to depend upon a rich form of human-human communication to be managed when the people concerned have to communicate in a virtual environment?" The comments from interviewees emphasise the relevance of this question; some of their main concerns with respect to efficiency in IO are related to lack of face to face communication, different professional and cultural backgrounds and insufficient understanding of roles and working environments. Efficient interaction and unambiguous communication are in principle important mitigating factors in an environment where vulnerability exists as a consequence of shortcomings related to the communication technology and the complexity embedded in these processes. The fact that the mitigating factors are also subject to significant challenges should be emphasised as an important concern.

The introduction of IO re-engineers conventional practice, making the O&G industry more technology-based, information dependent, and knowledge driven (Liyanage et al. 2007; OLF, 2007). The combination of increasing technological complexity and the virtual organisations characterising Integrated Operations suggests that the vulnerability embedded in the interface between those two enablers should be a focal area in the further development of this concept.

The findings identify a number of elements which both individually and in combination entail vulnerability in the interface between onshore personnel and collaboration technology.

In addition to features attributed to the ICT systems and data flow, key contributors to the vulnerability are associated with individual experience amongst employees in the onshore teams, in particular lack of offshore experience and –knowledge. Language barriers and cultural differences in multicultural teams are frequently mentioned as a challenge for efficient interaction. By nature, virtual teams are unstable in terms of team membership and hence, another factor contributing to the vulnerable nature of this socio-technical interaction is the lack of familiarity and trust among virtual team members.

The findings indicate that successful utilisation of ICT-mediated collaboration depends heavily on social interaction skills which are hard to attain in teams of this nature. Sociotechnical focus is therefore vitally important to the design, development, implementation, and use of the information technology communication systems.

4.2.3 Potential areas of improvement

Based on the findings, potential areas of improvement mainly fall under the categories *team properties* and *collaboration technology* and -*interface*.

4.2.3.1 Team properties

Individual knowledge and experience (in particular sufficient offshore experience amongst team members in the onshore teams), multicultural issues including language skills as well as team dynamics have been presented as important features where the interviewees identify challenges. This suggests that the operating companies could benefit from taking a more methodical approach to team selection to ensure a workable balance of skill sets and experience.

During the interviews, knowledge gaps (e.g. language and IT skills) have been identified. Systematic competence mapping, gap analyses and relevant training programmes should be considered as a measure to close the gaps identified. Awareness training aiming to enable team members to better handle challenges related to a multicultural environment is a potential area worth exploring.

Knowledge and tools based on the field of group dynamics may be useful in identifying relevant focal areas for improving collegial relations, building trust, improving decision making and ensuring the right level of involvement by the team members.

4.2.3.2 Collaboration technology and -interface

The findings of this research reveal a potential for further development of the technical platform and interface between people and technology under the IO concept. Effective and efficient communication systems and infrastructure constitute a prerequisite for optimal IO-solutions. Concerns have been raised by the interviewees pertaining to possible technological vulnerability due to poor data links between on- and offshore, computer crashes and programme failures. Furthermore, consequences of complex and in some cases inadequate digital infrastructure and poor data quality give rise to challenges in interpretation of real-time data.

A more mature technical platform, focusing on technical integrity, usability and a higher degree of standardisation are all improvement areas that can be deducted from the information provided by the interviewees. Moreover, the information provided clearly suggests that attention should be paid to optimising the presentation of data and disbursing data at a pace and volume that the operators are able to manage.

4.2.4 Socio-technical implications

Findings from the interviews illustrate that IO is a field characterised by interdependencies. This is supported by the basic principles of the IO elements stack model presented in section 2.2.

The underlying premise of socio-technical thinking is that systems design should be a process that takes into account both social and technical factors that influence the functionality and usage of ICT-based systems (Coakes &Coakes, 2011). Failure to fully recognising socio-technical aspects may increase the risk that systems will not meet their expectations with respect to supporting the aims and requirements for their intended application. The potential embedded in the available technology will only be fully utilised if it is adapted to the operators and their collaborative environment. The findings, in particular many of the examples presented in sections 4.1.5 and 4.1.6 above, illustrate that socio-technical implications exist in the application of ICT mediated collaboration. The interviewees clearly indicate that the solutions are not always optimised in a socio-technical perspective. The findings form the basis for a number of potential areas for improvement presented in section 4.2.3 above.

5 CONCLUSION

The main aim for this study has been to explore implications of ICT mediated collaboration in relation to geographically separate collaboration facilities. Limiting the scope and perspective to onshore personnel supporting offshore drilling operations, the main objectives have been to identify potential challenges due to the dependency on collaboration technology, increasing the insight into potential vulnerabilities arising in the interface between the operators and the collaboration technology and contributing to insight on potential areas of improvement.

Notwithstanding the numerous challenges and concerns pertaining to implementation of IO, the interviewees emphasised that substantial improvement can be attributed to the concept. The findings represent information about current concerns and challenges faced by industry professionals in the operational context of IO. The interviews revealed a potential for further improvement of the integration between onshore and offshore; service companies involved in the operation, various disciplines and functions in the operating company, in particular within the areas of communication and collaboration.

Based on the findings, potential areas of improvement mainly falling under the categories team properties and collaboration technology and –interface have been identified.

5.1 FURTHER RESEARCH

Due to the limited number of interviewees the results of the present study does not provide an exhaustive documentation or description of potential challenges faced by onshore personnel supporting offshore drilling operations. Nevertheless, the results are considered valid as a foundation for further research as they represent the experiences and opinions of personnel working in current IO-solutions. Furthermore, as the risk potential inherent in drilling operations is indisputable (PTIL, 2011) the results also indicate a *need* for further research.

As previously stated, a significant limitation of this study is that the results represent an onshore perspective only. Further research would benefit from including the experience and opinions of offshore personnel as this may ensure more adequate evaluations about which

issues that are prominent and to which extent. A large scale survey would be useful to further explore and map potential issues and would also support more robust conclusions.

The findings of this study manifest themselves in the interface between humans and technology and underpin the importance of a holistic socio-technical approach when developing and implementing IO. Proper understanding of socio-technical dimensions is critical for the O&G industry to avoid vulnerabilities and risks (Liyanage & Bjerkebæk, 2008). Further studies are encouraged to systematically identify and evaluate the critical interplay between social and technical aspects and identify issues arising from insufficient and ineffective interplay among the elements in a socio-technical system. In this context, factors that potentially could contribute to human error represent an important field of research.

Moreover, risks related to failure or breakdown in ICT systems and the potential consequences of incidents of this nature is regarded an important field for further research which may result in valuable contributions to the on-going effort to reduce operational risk. Drilling operations involve high-risk and complex operations and represent a significant contribution to the overall risk of major accident on the NCS (White Paper no.12; PTIL, 2011; Grøtan et al, 2010). This fact suggests further research focusing on potential risks that manifest themselves in the interface between humans and technology and risk-contributing factors that might arise due to increasing ICT dependence in the drilling operations.

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7 APPENDICES

APPENDIX 1 - INTERVIEW GUIDE

Interview Guide

Introduction:

- Introduction of the study theme and purpose
- Terms for the interview – reference to the information sheet to the interviewee
- Signing of declaration of consent
- Information about the informant (position, role, seniority etc.)

Main Topic/	Sub-Questions/themes
General on IO implementation	• Time since implementation, major steps in terms of system redesign and improvement, organisational change etc. since the start. • On an overall level, what works well? • What are the main challenges? • Please describe the main focal areas for further improvement of the IO concept.
ICT-based Collaboration	• What do you see as the most limiting factors to good communication and collaboration related to your solution? • What do you do to facilitate and enable collaboration? • Please describe the main concerns raised by the operators.

Digital Infrastructure	• What are the most important success criteria for systems design?
	• Can you identify the most significant challenges with respect to
	  ○ User interface
	  ○ Accessibility
	  ○ Stability

Collaboration between onshore and offshore	• Challenges due to dependence on ICT based collaboration. • What are the main limitations and obstacles for collaboration between on- and offshore? • What are the main enablers for collaboration between on- and offshore? ○ Any absolute pre-requisites?
Acquisition and processing of real-time data	• What are the main challenges with respect to capturing real time data?

APPENDIX 2 – INFORMATION TO THE INTERVIEWEE

Information to the Interviewee

The interview will be executed in a conversational manner. I am interested in your knowledge and experience on the subject of inquiry. There are no set answers to the questions. The duration of the interview will be approximately one and a half hours.

If you consent, I would like to record the interview to ensure the accurate replication of the information you provide. The recording will be destroyed when the study is accomplished. You may withdraw from the interview at any time, without stating any reason. If you choose to withdraw, all information provided from you will be deleted immediately.

The information you provide will be treated confidentially. No single results will be published – only aggregated anonymous data. This implies that readers of the study will not be able to identify the individual interviewee's or company's response.

As long as the study is in progress, you are entitled to accessing the information you have provided. If desired, this can be sent to you via e-mail for perusal.

If you have any queries or comments to the study, please contact the undersigned at any time; Nina Finstad via email: nina.finstad@outlook.com or by phone: 92080154.

In advance, thank you for your participation.

Regards,

Nina Finstad

APPENDIX 3 – INFORMASJON TIL INFORMANTEN

Informasjon til informanten

Intervjuet vil foregå som en samtale. Det finnes ingen fasitsvar på spørsmålene. Jeg er interessert i din kunnskap og erfaring omkring emnet. Samtalen vil ta omtrent 1 ½ time.

Dersom det er greit, ønsker jeg å ta opp samtalen elektronisk, for at nedtegnelsen av dine opplysninger skal bli så nøyaktig som mulig. Lydopptak destrueres når studien er ferdigstilt. Du har mulighet til å trekke deg når som helst underveis i samtalen, uten å måtte begrunne dette nærmere. Dersom du trekker deg vil all innsamlet informasjon fra deg slettes.

Opplysninger vil bli behandlet konfidensielt. Ingen enkeltresultater vil bli offentliggjort – kun samlede anonymiserte data. Det betyr at lesere av studien ikke skal kunne identifisere den enkelte informants eller selskaps svar.

Så lenge studien pågår har du rett til innsyn i de opplysninger du har gitt. Hvis ønskelig kan informasjon du har meddelt sendes til deg via e-post for gjennomlesning.

Har du spørsmål eller kommentarer til studien i forkant eller etterkant, kan du kontakte undertegnede; Nina Finstad via mail: nina.finstad@outlook.com eller på tlf. 92080154.

På forhånd tusen takk for at du ville delta.

Med vennlig hilsen,

Nina Finstad