Defined Situations of Hazard and Accident related to Integrated Operations on the Norwegian Continental Shelf

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Abstract
The report studies the extent to which there is a need for establishing new Defined Situations of Hazard and Accident (DSHA) when Integrated Operations (IO) is introduced. A literature review and an interview study show that there currently is no need for changing the DSHAs currently used in the industry, as the overall types of accidents that may arise in an IO environment are foreseen to be similar to the types of accidents that may arise in a traditional operational environment. It further reveals that the IO development produces a need for establishing a new ICT-related DSHA. It is also shown that the IO development influences the causal chains of leading to DSHAs. This impacts emergency handling, and implies that training scenarios should be revised when IO is introduced.

Keywords
- Safety
- Offshore
- Integrated operations
- DSHA
- Emergency preparedness

English Norwegian
Sikkerhet
Offshore
Integrete operasjoner
DFU
Beredskap
Executive Summary

The purpose of this study has been to describe Defined Situations of Hazard and Accident (DSHA) currently applied by the industry and to explore the demand for new or changed DSHAs related to an Integrated Operations (IO) environment. Opportunities and challenges for use of DSHAs in an IO context were also explored.

A literature review on IO and safety issues in addition to an interview study were performed to approach this purpose. Five interviews with central stakeholders in the Norwegian petroleum industry were made to study DSHAs currently applied by the companies and how the current DSHAs were used, produced and updated. The interviews provided good insight into IO and DSHAs, however due to the small sample the interview results should not be treated as generalized facts.

The interviews indicate that existing DSHAs are looked at just as valid in an IO setting as within traditional operations. Based on the interviews, it can not be claimed that there is any impact on existing DSHAs by IO. The main reason for this is that the DSHAs are events that remain the same in IO as in traditional operations (e.g. a hydrocarbon leak occurring close to an ignition source is just as threatening in IO as in any other way we operate). The interviews show that IO-DSHAs have not been developed because companies have not identified any new incident/accident events that may negatively impact humans, material, the environment and/or reputation associated with the introduction of IO. Several of the interviewees stated that even though the introduction of IO implies a range of changes in what, how and where tasks are performed, it does not lead to significant change in the underlying physical processes. The present approach for developing DSHA-sets today implies that DSHAs constitute as top-events, i.e., they constitute events that imply or may directly lead to fatalities, damages, etc. When IO is introduced, the manner in which work is carried out at the installations, changes. Rather than impacting top events, these changes can be expected to impact the type of occurrences that constitute initiating events, i.e., the type of events that may precede the occurrence of a top-event. As long as DSHAs are developed from a present perspective, i.e. that they are regarded as top-events, the introduction of IO may not necessarily come to impact the DSHAs used.

The interviews and the literature survey indicate that one aspect of IO that may require a new DSHA is the increased ICT dependency. This dependency creates new types of risk related to: communication and information transfer between the production/operation site and the operation centre/support centre onshore; ICT-based process-control systems; and power and ICT failures in control rooms. Risk due to ICT dependencies may be initiated by both malicious/criminal acts and accidental events.

The literature points out several factors influencing safety that become more relevant in an IO context: ICT systems; maintenance activities; new contexts for decision making; collaboration independent of location, organization and discipline; shared situational awareness; increased complexity and interactivity; information overload; new ways for communication; automation of normal operation; blurred responsibilities; new work organizations and teamwork. These factors must be considered when analyzing the chain of events related to current DSHAs as well as for handling events.

The interviews indicate that the main changes in use of DSHAs within an IO setting is related to the way deviances and emergencies are handled. These changes are related to: 1st and 2nd
line of emergency resources; group mechanisms; situational awareness; power issues; the transition from normal integrated operation to crisis handling; integration of contractors; and coordination of different actors. These aspects create *new challenges when it comes to training and emergency exercises in IO*.

The present study is exploratory in nature, and does not provide a final answer to the question of whether IO-DSHAs will be needed. For this reason, it is important to further explore the proposed new DSHAs (lack of ICT systems) indicated in this study, as well as studying the build-up of emergencies and emergency handling in an IO environment. For further research, we suggest that an observation study is carried out to uncover concrete changes related to the rise and handling of existing DSHAs in an IO environment, as compared to a traditional operational environment. Identifying the concrete changes could contribute to further quality of the answer to the question of whether there is a need for IO-DSHAs. This type of study should pay particular attention to the possible relevance of the proposed new DSHA “lack of ICT systems,” by assessing the consequences that failure/breakdown in ICT systems could have at different times, as the situation unfolds. In addition, comparing deviation logs between IO installations and traditional installations would provide concrete information about the extent to which the challenges faced in the two types of operational settings differ. Revision of training scenarios to accommodate changes in the chain of events leading to accidents is an issue of key concern. The suggested research approach would contribute to the basis for identifying the type of changes that need to be introduced in training scenarios and drills.
Preface

This report is produced within the subproject “Integrated Operations and Safety” at the Center for Integrated Operations in the Petroleum industry. The center is established by NTNU, SINTEF and IFE, in collaboration with major international oil companies and suppliers (Aker Solutions; ConocoPhillips; Det norske veritas; ENI Norge; FMC Technologies; Gaz de France; IBM; Kongsberg Maritime; Shell; StatoilHydro; Total)

The present study contributes to the discussion of whether there is a need for establishing new Defined Situations of Hazard and Accident (DSHAs) when integrated operations (IO) is introduced. The study includes a literature survey and an interview study. The authors thank the interviewees for sharing their knowledge.
1 Introduction

The concept *Defined situations of hazard and accident* (DSHAs) is used by petroleum companies operating on the Norwegian Continental Shelf to specify a selection of hazardous and accidental events, based on which emergency preparedness can be established (NORSOK Z-013, page 5). Examples of common DSHAs across the industry are, e.g., hydrocarbon leaks, well kick/loss, fire/explosions, and man over board. The philosophy is that the risk for accidents associated with petroleum production will be effectively reduced, if the petroleum companies protect against the occurrence of the DSHAs, and protect against the negative impacts that may follow, should the DSHAs occur. The DSHAs currently applied in the petroleum industry have been established based on risk analyses of hazards associated with petroleum production in a traditional operational environment, and thus prior to the introduction of integrated operations.

![Figure 1. OLF’s (2005, 9) suggestion as to what the characteristics of IO will be across time.](image)

The concept *integrated operations* (IO) has been defined in different ways. The Norwegian Ministry of Petroleum and Energy (2003-2004) states that IO implies: “...use of information technology to change work processes to achieve improved decisions, to remotely control equipment and processes, and to relocate functions and personnel onshore.” Another definition of IO has been proposed by Ringstad and Andersen (2007). They define IO as “new work processes which use real time data to improve the collaboration between disciplines, organizations, companies and locations to achieve safety, better and faster decisions” (*ibid*, 1). The Norwegian Oil Industry Association (OLF) predicts that the content of IO will change over time, and outlines two IO generations (OLF, 2005) (see Figure 1). The *first generation* will integrate the work processes between staff onshore and offshore using information and communication technology (ICT), and overall improve onshore staff’s ability to support offshore operation. This will imply that decision processes are made in real-time collaboration between integrated onshore and offshore teams. The *second generation* will imply a closer integration between operators and vendors, to facilitate efficient utilization of the vendor’s
competencies and services by the operator. The second generation will, further, be associated with more automated processes, digital services and 24/7 operations. This is foreseen to allow the operator to “…update reservoir models, drilling targets and well trajectories as wells are drilled, manage well completions remotely, optimize production from reservoir to export lines, and implement condition-based maintenance concepts” (ibid., 3).

Ringstad and Andersen (2007) discuss how IO more concretely will impact the ways of working in the petroleum industry. They argue that the work processes in an IO environment, as compared to in a traditional operational environment, can be characterized as parallel, multi-discipline, independent of physical location, involving decision making in real-time, and implying a proactive perspective (Table 1).

Table 1. Ringstad and Andersen’s (2006) vision of how IO will change the ways of working in petroleum companies.

<table>
<thead>
<tr>
<th>Traditional way of working</th>
<th>IO way of working</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial</td>
<td>Parallel</td>
</tr>
<tr>
<td>Single discipline</td>
<td>Multi discipline</td>
</tr>
<tr>
<td>Dependence of physical location</td>
<td>Independence of physical location</td>
</tr>
<tr>
<td>Decisions are made based on historical data</td>
<td>Decisions are made based on real-time data</td>
</tr>
<tr>
<td>Reactive</td>
<td>Proactive</td>
</tr>
</tbody>
</table>

Even though the concept of IO has not yet obtained a commonly agreed upon definition, and the precise consequences of IO have still not been determined, it is clear that IO will come to change the work processes in the organization, as well as the companies’ infrastructure – including the collaboration technology applied.

To ensure that the safety level at the Norwegian Continental Shelf will still be acceptable when IO is introduced on a large-scale, it is important to assess whether the present DSHAs adequately cover all hazards that may be influenced by an IO environment. The present study contributes to the discussion of whether there is a need for establishing IO-related DSHAs, and, if this is the case, what the IO-DSHAs may look like. The study has the following objectives:

- Describe requirements to and content of DSHAs currently applied by the industry.
- Explore the demand for new or changed DSHAs related to the IO development
- Explore opportunities and challenges for use of DSHAs in an IO context

The study uses two research approaches. First, a limited-scale literature survey is performed. The purpose of the survey was to clarify whether indications on the need for IO-related DSHAs could be found and/or alternatively, whether other indications on the need for IO-DSHAs were documented. Second, a set of interviews were performed with central stakeholders in the petroleum industry at the Norwegian Continental Shelf to uncover the industry’s current view on the possible need for establishing IO-related DSHAs.

It might be argued that the timing of the present study is premature. Since no unanimous agreements currently exists within the petroleum industry with respect to how the concept IO should be defined, it is difficult to account for the extent to which IO is applied by the different companies. Accordingly, it is also difficult to determine the extent to which data obtained with reference to ‘an IO environment’ is in fact “pure” IO data, or rather represent a mixture of IO and traditional work practices data. On the other hand, it might also be argued that the present study is particularly timely indeed, because it contributes proactively to
identify possible IO-related DSHAs (at least as we presently foresee an IO environment to
be). It will thus contribute to allow definition of IO-related DSHAs and the associated
emergency preparedness initiatives prior to a large-scale transfer to IO at the Norwegian
Continental Shelf, and thus potentially to reduce the risk for future accidents.

The report is organized as follow: Chapter 2 provides an account for the requirements to
DSHAs and presents the typical content of the standard DSHA-sets used today. Chapter 3
accounts for the outcome of the literature survey. Chapter 4 reports the outcome of the
interview study. Chapter 5 discusses the joint outcomes of the literature survey and the
interview study. Finally, chapter 6 presents the conclusion on the present study, and outlines a
possible course for future research.
2 Defined Situations of Hazard and Accident – Requirements and Type of Content

This chapter provides the background for a discussion of the need for specific IO-DSHAs. It contains a brief introduction to present requirements to DSHAs, as specified in the regulations of Petroleum Safety Authority Norway (PSAN), and presents the DSHAs used by PSAN in the “Trends in risk level” project (RNNP) to exemplify what a current DSHA-set may look like.

The Petroleum Law (Petroleumsloven, 1996, section 9-2, our translations) specifies that the company, which holds the overall responsibility for the activities in question, i.e. the party responsible, also called “the operator,” is responsible for ensuring that efficient emergency preparedness is established “… to meet situations with hazards and accidents that may result in loss of human live or personal injury, pollution or major material damage.” It further specifies that the party responsible is ”.... obliged to ensure that necessary measures are established to prevent or reduce harmful effects, including to the extent possible what is necessary to restore the environment to the state prior to the accident happened […].”

The party responsible must adhere to the regulations issued by the PSAN. The Framework Regulations constitute the basic frame of reference for all other regulations issued by the PSAN. The Framework Regulations specify that the party responsible, is obliged to take the steps required to protect people, the environment and financial assets:

“Harm or danger of harm to people, the environment or to financial assets shall be prevented or limited in accordance with the legislation relating to health, the environment and safety, including internal requirements and acceptance criteria.” (Framework Regulations, section 9).

What this concretely implies is addressed in more details in the Management Regulations. The first section of the Management Regulations states that “…the party responsible shall choose technical, operational and organisational solutions which reduce the probability that failures and situations of hazard and accident will occur.” It is, furthermore, stated that barriers shall be established to reduce the probability and/or limited possible harm and nuisance that may follow from failures and situations of hazard and accident.

The phrases ‘situations of hazard and accident’ and the related phase ‘defined situations of hazard and accident (DSHA)” are of key importance in the regulations. The Management Regulations, section 15, specify that the party responsible shall perform a quantitative analysis of the risk associated with its activities. They further require that the risk analysis shall include identification of situations of hazard and accidents. The same requirement is found later in section 15 in relation to emergency preparedness: To ensure an adequate level of preparedness, the party responsible shall 1) define situations of hazard and accident, 2) set performance requirements to the emergency preparedness, and 3) select and dimension emergency preparedness measures.

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1 Risikonivå i Norsk petroleumsvirksomhet
2 In Norwegian the acronym DFU is used. It refers to ‘Definerte fare- og ulykkesituasjoner.’ The term DFU is also used in the Petroleum Safety Authority Norway’s English translation of the regulations
The regulations of PSAN are generally formulated in functional terms: They document what goals the operator (party responsible) shall fulfill, but not how the goals should be fulfilled. The regulations, thus, leave it to the operators to determine the actual number and content of the DSHAs. However, in the guidance document to the Management Regulations it is stated that to fulfill the requirements regarding quantitative risk assessments and emergency preparedness analysis, the standard NORSOK Z-013 ought to be used. Figure 2 shows how DSHAs are established in the Emergency Preparedness Analysis (EPA) process.

Figure 2. Risk analysis and emergency preparedness analysis (NORSOK standard Z-013, page 15).

The standard states that DSHA shall include the following event categories (NORSOK Z-013, 15):

- Dimensioning accidental events (DAE), i.e., events that serve as the basis for layout, dimensioning and use of installations and the activity in large to meet the defined risk acceptance criteria), usually defines on the basis of the risk analysis;
- Less extensive accidental events (AE), including acute cases of illness;
- Situations with temporary increase of risk.

Additionally, the standard states that DSHAs shall be established on the basis of:
- Events that have been experienced in comparable activities.
- Accidental events that appear in quantitative risk analysis (QRA) without being identified as DAEs, as long as they represent
- Separate challenges to the emergency preparedness.
- DSHAs according to OLF Guidelines for Area-based Emergency Preparedness (OLF, 2000).³
- Events for which emergency preparedness exists according to normal practice.

The Management Regulations, section 19, further require that the party responsible shall record and examine situations in which hazard and accident situations have occurred, both in cases where they have lead to injury and in cases where they could have lead to injury, harm or pollution. The purpose is to prevent recurrences of situations of hazards and accidents.

To provide a concrete example of a DSHA-set used in the Norwegian petroleum industry, the company-independent set of DSHAs used by PSAN in the "Trends in risk level" (RNNP) project (RNNP) is presented below. The DSHA-set of the RNNP project was established to provide a basis for calculating statistics on incident/accident events on the Norwegian Continental Shelf. It thus to serve a different purpose than the DSHAs applied in the petroleum companies. However, the DSHA-set of the RNNP/PSAN to a large degree covers the same type of events, as the standard DSHA-sets of the companies (see further in section 4.2).

The DSHA-set of the RNNP/PSAN was established based on the following two criteria (Norwegian Petroleum Directorate et al., 2001, 11):

1) The DSHAs should jointly cover all known events that can lead to accidents involving loss of lives. An exception is occupational accidents/incidents which is also included. Thus, all chain of events that can result in loss of lives will include one or more of the DSHAs. The extent to which a DSHA will lead to loss of lives, depend on the barriers that will impact the event chain.

2) Availability and quality of information about the individual DSHA: DSHAs must be observable and preferably high-quality data about its occurrence should be available.

The DSHAs defined by the RNNP project comprise both indicators on large-scale accidents and on non large-scale accidents, including temporary risk increases. When used in the context of the RNNP project, the term ‘major accidents’ is generally understood as follows: “Large-scale accidents are caused by failures in one or more of the safety and emergency barriers contained by a system” (Norwegian Petroleum Directorate, 2003, 11, our translation). The set of DSHAs established within the framework of the RNNP project was assumed to constitute events that were investigated by the petroleum industry in year 2000 (Norwegian Petroleum Directorate et al., 2001).

The DSHAs reported in 2001 still, with certain modifications, serve as basis for assessments in the RNNP project in year 2008 (see Table 2).

All the DSHAs established by the RNNP project were perceived to be valid for production installations, i.e. all types of installations that are use with production purposes, including

³ Area-based emergency preparedness concerns those DSHA situations, which an offshore installation cannot handle without assistance from external parties. To establish cooperation about common emergency resources in a specific area, the PSAN must approve the joining installations individually. OLF (2000) suggests that the following DSHAs are to be included in area-based emergency preparedness: Man over board, personnel in the sea due to a helicopter accident, personnel in the sea due to emergency evacuation, risk for collision, acute oil spill, fire that requires external assistance, and acute medical emergency that requires external assistance (OLF, 2000, 8, our translation). For each of these DSHAs, the report suggests capacity and efficiency requirements in to the emergency preparedness.
storage ships. They were also perceived to be valid for mobile units, except for DSHAs: 9, 10, 19, 23, and 24.

The PSAN regulations have not been markedly revised with respect to the requirement concerning establishing and use of DSHAs since 2001. For this reason, the above requirements to DSHAs should also meet, when the need for IO-DSHAs are debated.
Table 2. Overview of the original DSHAs applied in the RNNP project (Norwegian Petroleum Directorate et al., 2001, 12-13) [Our translations of DSHA 22-24], including important changes and modifications since then. Note: The DSHAs in italic is no longer used by the RNNP project.

<table>
<thead>
<tr>
<th>No</th>
<th>Original DSHA description</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-ignited hydrocarbon leaks.</td>
<td>Large-scale accident indicators.</td>
</tr>
<tr>
<td>2</td>
<td>Ignited hydrocarbon leaks.</td>
<td>DSHA-10 and DSHA-11 are in principle indicators on large-scale accidents. However, in the RNNP project, they are not used as such (see, e.g. Petroleum Safety Authority Norway, 2008).</td>
</tr>
<tr>
<td>3</td>
<td>Well kicks/loss of well control.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fire/explosion in other areas, flammable liquids.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Vessel on collision course.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Drifting object.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Collision with field-related vessel/installation/shuttle tanker.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Structural damage to platform/stability/anchoring/positioning failure.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Leaking from subsea production systems/pipelines/risers/flowlines/loading buoys/loading hoses.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Damage to subsea production equipment/pipeline systems/diving equipment caused by fishing gear.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Evacuation.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Helicopter crash/emergency landing on/near installation. Later: Helicopter occurrence.</td>
<td>Non large-scale accident indicators:</td>
</tr>
<tr>
<td>13</td>
<td>Man overboard.</td>
<td>DSHA-17 and DSHA-20 were excluded from phase 6 of the RNNP project. (Norwegian Petroleum Directorate, 2006, 18).</td>
</tr>
<tr>
<td>14</td>
<td>Serious injury to personnel.</td>
<td>DSHAs 22-24 were not used in the 2002 assessment. The feedback from the companies was that the reporting related to these DSHAs first would be complete from 1.1.2002 (Norwegian Petroleum Directorate, 2003, 6). However, these indicators were not used in later risk assessments either (see: Petroleum Safety Authority Norway, 2005; 2006; 2008).</td>
</tr>
<tr>
<td>15</td>
<td>Occupational illness.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Total power failure.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Control room out of service.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Diving accident</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>H²S emission</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Lost control of radio-active source.</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Falling object.</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Acute pollution.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Production halt.</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Transport system halt.</td>
<td></td>
</tr>
</tbody>
</table>

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4 The Norwegian Petroleum Directorate (now: Petroleum Safety Authority Norway) later redefined this indicator. Originally, DSHA-12 only comprised transportation of persons using helicopter within the safety zone of an installation. In a later report (Norwegian Petroleum Directorate, 2003, 10) the indicator was redefined to include all transport of persons using helicopter related to the petroleum industry at the Norwegian Continental Shelf. From this point on DSHA-12 was referred to as “Helicopter occurrence” (my translation). The DSHA-12 is still included as an indicator of large-scale accidents. However, as such it only includes possible large-scale accidents at/near by an installation, i.e. events accounted in DSHA 1-10 (Petroleum Safety Authority Norway, 2005, 16).
3 Literature Survey

A literature survey was performed to clarify whether indications on the need for IO-related DSHAs could be found and/or alternatively, whether other indications on the need for IO-DSHAs were documented.

3.1 Method

The literature survey included recent reports and papers based on one main criterion: The reports/papers should be recent, and address IO in the petroleum industry at the Norwegian Continental Shelf. For practical reasons, the survey had to be limited in scope. It comprised 12 reports/papers, which were identified based on the former experiences of the authors of the present report and recommendations from contact persons in the industry. The reports/papers included were: Andresen, Grøtan, Johnsen, Rosness, Sivertsen, Steiro, Thunem, and Tveiten (2006), Ringstad and Andersen (2006), Grøtan and Albrechtsen (2008), Johnsen (2008), Johnsen, Ask and Røisli (2007), Johnsen, Bjørkli, Steiro, Fartum, Haukenes, Ramberg, and Skriver (2008), Øien and Schjølberg (2008), OLF (2007), Ringstad and Andersen (2007), Skarholt, Næsje, Hepsø, and Bye (2008), Tveiten, Andersen, Rosness, and Tinmannsvik (2008b), and Tveiten, Lunde-Hanssen, Grøtan, and Pehrsen (2008a).

For each report/paper the following issues were documented:

1) The purpose of the report/paper.
2) The rational for recommending that IO-related DSHA should/should not be developed.
3) Specific suggestions for IO-related DSHAs.
4) Other issues covered that could be of key concern when assessing the need for IO DSHAs.

It should be noted that points 2-4 were not covered in all of the reports/papers reviewed.

3.2 Results

The outcome of the brief literature survey is presented in the three following sections. The suggestions for IO-DSHAs contained in the reviewed reports/papers are documented in section 3.2.1. Section 3.2.2 outlines and discusses a set of the issues covered in the reports/papers, which should be taken into considerations in assessments of the need for establishing IO-DSHAs. Finally, section 3.2.3 summarizes and concludes on the findings in the survey.

3.2.1 The Need for IO-related DSHAs

Except for one report, none of the reports and papers reviewed explicitly addressed the issue of DSHAs from an IO perspective.

In the OLF report from 2007 entitled Integrerte Operasjoner Akselerert utvikling på norsk sokkel, OLF emphasizes that actors in the petroleum industry must adjust their routines with respect to documentation and risk assessments, when IO is introduced. Even though the requirement is formulated in general terms, this includes adjustments of DSHAs during the process of introducing IO.

Grøtan and Albrechtsen (2008) in their report entitled Risikokartlegging og analyse av Integrerte Operasjoner (IO) med fokus på å synliggjøre kritiske MTO aspekter argue that some of the existing methods for risk analysis and emergency preparedness analysis can be
used in an IO environment, but that input to the risk models must be related to the IO-development. Since DSHAs (often) constitute the point of reference in risk analyses and emergency preparedness analyses, this implies that also the DSHAs will have to be accommodated (if necessary) to the IO environment.

The only report/paper that explicitly addressed the issue of DSHAs from an IO perspective was Tveiten, Lunde-Hanssen, Grotan, and Pehrsen (2008a). In their report entitled *Hva innebærer egentlig Integrerte Operasjoner? Fenomenforståelse og generiske elementer med mulige konsekvenser for storulykkespotensiаlet*, they state that the DSHAs of today are not adapted to IO. They emphasize that this may turn out to be critical: Since *it cannot be taken for granted that IO-related hazards are covered by the existing DSHAs, it cannot be taken for granted that all IO-related hazards are addressed in (emergency) training sessions.* Tveiten *et al.* (2008a) argue that with the introduction of IO, it will as a minimum be necessary to update the DSHA-based scenarios applied in training programs, to include the new groups of actors and systems that are involved in the virtual organization structures.

Tveiten *et al.* is, moreover, the only report that explicitly suggests an IO-related DSHA: *failure in ICT systems*:

“It is seen as a major risk that failure in ICT systems is not included in the usual DSHA analyses. When IO is applied, situations that involve a breakdown in the communication lines or other ICT related scenarios are relevant as DSHA-elements to ensure that these are taken into consideration in risk analyses, education, training, etc.” (Tveiten *et al.*, 2008a, 16)

During the course of the present study we learned that Det Norske Veritas (DNV) had addressed the issue of whether there is a need for developing IO DSHAs (Ask, *personal communication*). In particular, the possible relevance of two IO-DSHAs related to information security had been considered at the DNV:

- Unauthorized activities in the process-control network
- Loss/Reduced control of the process-control system (ICT/PCSS)

Presently, this issue is not further pursued at the DNV.

### 3.2.2 Related Issues

A range of the factors addressed in the reports/papers surveyed has clearly potential implications for assessments of the need for IO DSHAs. This in particular concerned factors, which were suggested to be radically different and/or more challenging in an IO environment as compared to in a traditional operational environment. The main factors of this type will be discussed below under the following three headings:

- ICT infrastructure;
- Training, teamwork, collaboration technology, and work organization;
- Maintenance.

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5 The report also presents two future scenarios where lack of ICT-resources are among the main causes to incidents
ICT Infrastructure

Several of the papers/reports surveyed focused on the critical importance of ICT infrastructure in an IO environment, without addressing the implications of these changes for the DSHAs. Ringstad and Andersen (2006) performed a study that identified pros and cons associated with early attempts to implement IO. Their study was based on a comprehensive and varied set of data: 21 visits to offshore operations centers in Norway and the US, 22 interviews with important stakeholders in Statoil, a survey of the experiences and results from Statoil’s early IO pilot projects, and a survey of the literature on IO. One of the main HSE challenges identified in relation to the topic accident risk was “Increased risk due to breakdown in on-offshore communication” (Ringstad and Andersen, 2006, 4). This was considered to be a challenge based on the assumption that there may be a lack of staff off-shore to adequately handle accident situations in an IO environment.

Skarholt, Næsje, Hepsø, and Bye (2008) performed a study to obtain a better understanding of how leadership is impacted by the use of advanced information and communication technology in an IO environment, based on data obtained from an IO environment, i.e., the Kirstin asset. Among other things, Skarholt et al. emphasize the close collaboration they have observed between management teams offshore and management teams onshore. This finding may support the view that a breakdown in offshore-onshore communication could have more severe consequences in an IO environment, than in a traditional operational environment where the staffing level offshore is higher.

Andresen, Grøtan, Johnsen, Rosness, Sivertsen, Steiro, Thunem, and Tveiten (2006) discuss the challenges that may be associated with co-operation across distances in an IO environment. Andresen et al. (2006, 10) stress that digital infrastructure should be characterized as critical infrastructure, in the sense that both break downs and infrastructure capacity reductions may have serious consequences for HSE, information security of information, and/or economy.

In the report documenting the revised version of the Crisis Intervention in Offshore Production (CRIOP) methodology, Johnsen, Bjørkli, Steiro, Fartum, Haukenes, Ramberg, and Skriver (2008, Appendix A, VIII) include a scenario called: ICT and SAS\(^6\) systems breakdown and loss of communication. This scenario implies that the ICT system and the main part of the SAS system have a common failure, and the inclusion emphasizes the importance of maintaining onshore-offshore communication in an IO environment. Johnsen (2008) shows how ICT and SAS systems creates high complexity and tight coupling that creates an increased risk for major accidents for petroleum activities at the NCS. It is also emphasized that the coupling of ICT and SAS produces a new threat related to information security incidents (Johnsen, Ask and Roisli, 2007).

Jointly, the above findings may indicate that communication breakdown – and communication capacity reductions - between offshore and onshore units is a candidate for inclusion as an IO DSHA, as also suggested by Tveiten et al., 2008a (see section 3.2.1).

Training, Teamwork, Collaboration Technology, and Work Organization

Ringstad and Andersen (2007) focus on the actual implementation of IO at the Tampen area, and account for how potential drawbacks of IO were met in this process. They outline five

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\(^6\) SAS is an acronym for “Safety and Automation System.”
factors that may come to negatively impact employees’ decision making following the introduction of IO:

- A sceptical workforce resisting change
- Group based and distributed decision making that blur lines of command
- Information overload
- Reduced understanding of local (i.e. installation specific) factors
- Heightened complexity and interactivity.

The five factors may clearly come to impact the operational activities in an IO environment negatively, to the extent they are not adequately adhered to. For this reason, they should be considered in assessments of the need for IO-DSHAs. In particular, the five factors point to the need for assessment of the consequences that follow the introduction of IO on work organization and training requirements.

Ringstad and Andersen (2006, 4) find that “Increased risk of accidents because some decision makers will have reduced hands-on experience” is one of the main HSE challenges associated with accident risk in an IO environment. This finding contributes to stress the key importance of considering the changed requirements for training that will follow when IO is introduced.

Grøtan and Albrechtsen (2008) focus on the changes in human and organizational factors that will follow when IO is introduced, and on how these changes will come to impact the risk for major accidents. Grøtan and Albrechtsen argue that some of the existing methods for risk analysis and emergency preparedness analysis still can be used in an IO environment, but that the input to the risk models must be related to the IO-development. For example, IO-DSHAs may serve as input to emergency preparedness analyses. Grøtan and Albrechtsen provide an overview of the factors that can create or mitigate major accidents in an IO environment, and thus indicate what issues it will be important to address for prevention of situations of hazard and accident. These include:

- Failing coordination and collaboration between different actors regarding location, organization and discipline, e.g. between operators and integrated contractors.
- Challenges regarding change from normal operation to crisis handling, regarding e.g. distributed teams, ICT, automation of normal operation, responsibility, etc.
- New ways of communication
- Emphasis on development of new work processes without the same emphasis on work forms
- Challenges of new contexts for decision-making, e.g. common situational awareness, quick decisions without reflections, etc.
- More complex interactions and tight couplings due to information systems and new work forms

The issues outlined by Grøtan and Albrechtsen clearly indicate that teamwork, work organization, and collaboration technology are factors that should be considered in assessments of the need for IO-DSHAs.

Tveiten, Andersen, Rosness, and Tinmanusvik (2008b) address what factors that may contribute to situations of hazard and accidents with respect to teamwork, work organization, and collaboration technology in an IO environment. More specifically they address: collaboration, communication, roles, and responsibilities in integrated operations. In addition to these factors, they, moreover, identify a further challenge: that the concept of IO can be
understood differently by contractors and operators. This is due to the fact that contractors take part in sub-processes and limited parts of the operation whereas an operator coordinates all processes related to the operation as well as handling many sub-processes. Contractors can see limits in operations that are difficult to see for an operator in the same way as an operator can see challenges in the totality of processes. Integrated operations means possible integration of these two points of view related to hazards and DSHAs if integration in organisations includes contractors and other part time workers.

Andresen et al. (2006) focus on the impact of co-operation across distances on control-room operators’ ability to understand the situation at hand. They argue that ICT systems pre-structure the situational understanding of the control-room operators, because the systems force the operators to interpret the selected, de-contextualised, and abstract symbols, which the systems present, rather than the immediate physical responses generated by the different processes. Andresen et al. underline that the information conveyed by an ICT system is not identical to knowledge. To obtain knowledge, people have to combine, interpret, and make sense of the information, and this sensemaking process is continually on-going. The information provided by the systems, they argue, may lead to tensions and conflicts between the parties involved in a decision process, if the parties interpret the information differently. Such tensions and conflicts may potentially lead to a break-down in adequate situation understanding. Andresen et al. raise the question of “... whether both large-scale accidents and more “normal” accidents can be caused by a “breakdown” in joint/collective knowledge/knowing of obtaining knowledge/knowing” [our translation] (Andresen et al., 2006, 29). This discussion points indicate that achievement of correct shared situational understanding is more challenging in the virtual teams applied in an IO environment than in a traditional operational environment.

**Maintenance**

Tveiten et al. (2008a) argue that the higher level of integration between operators and suppliers/contractors and the higher level of outsourcing maintenance activities, which are foreseen to be used in an IO environment, may come to impact offshore maintenance negatively. More precisely, they focus on the potential impact of the so-called long-term integrated contractors/suppliers contracts. The intention of this type of contracts is to reduce the costs associated with running parallel organizations in the operator and supplier companies to maintain the needed level of competence, e.g., parallel organizations to maintain the required competence with respect to maintenance work. However, a study by Øien and Schjølberg (2008) shows that operators and entrepreneurs are at different levels in the IO development. Operating companies have mainly moved maintenance planning onshore and access to real time data increases the efficiency of this activity. However, entrepreneurs, which is claimed to become ‘integrated contractors’ in the IO development, call for a tighter collaboration with the operators, not least when it comes to access to data.

If the IO-development is accelerated regarding maintenance activities, Tveiten et al. point out that these long-term contracts may come to challenge the achievement of an adequate maintenance state, in situations where the need for activities beyond the normal/planned maintenance activities arises. They argue that the contractors’ profit margins as a starting point can be expected to be low, and that the contractors for this reason will seek to prevent that they are further reduced. Tveiten et al. (2008a) outline four challenges that may be associated with this situation:

- It is a challenge to ensure adequately that staff member will have adequate competence for handling situations that seldom occur.
- Integrated contract/suppliers contracts will imply reduced staffing offshore, and the installations will thus be more vulnerable for staff turn-over.
- It might be a challenge to ensure that staff members are available to participate in planning and implementation of change processes in the operator company, while at the same time effectively maintaining production.
- There may be challenges associated with respect to allocation of responsibly in situations where deviations occur, such as when unforeseen reservoir events occur.

The above may indicate that issues related to maintenance, and the overall maintenance state at an installation at any given time, should be addressed in assessments of the need for future IO-DSHAs.

### 3.2.3 Summary and Discussion

Although there has been a high focus on IO during the last years, we found that only one of the reports/papers included in the survey explicitly addressed the topic of DSHAs from an IO perspective. It could be that we have missed central reports, or that the topic simply not has been the subject of discussion in publicly available literature up till now.

This brief literature survey, however, clearly emphasizes the overall need for adapting methods and tools when the operational concept on the installations is changed from the classical (pre-IO) approach to IO. The literature identifies several risk influencing factors that become more relevant in an IO context: ICT systems and digital infrastructure; maintenance activities; new contexts for decision making; coordination and collaboration independent of location, organization and discipline; shared situational awareness; increased complexity and interactivity; information overload; new ways for communication; automation of normal operation; blurred responsibilities; new work organizations and teamwork. These factors can not be ignored when assessing the need for establishing IO-DSHAs. Moreover, the impacts of IO on the casual chains leading to the events should be clearly reflected in the scenarios used to train emergency handling in an IO environment.
4 Interview Study

The interview study was performed to uncover the industry’s current view on the possible need for establishing IO-related DSHAs.

4.1 Method

The interview study comprised 5 semi-structured interviews with central stakeholders in the petroleum industry at the Norwegian Continental Shelf. The interviewees represented four different oil companies; in addition, staff from the Petroleum Safety Authority Norway was interviewed. The interviews were performed in the period October 17, 2008 to November 27, 2008. They were carried out as group sessions with 1-3 interviewees and 1-2 interviewers present, and each interview lasted between 1 and 2 hours. Prior to the interviews, a letter of introduction and the interview guide was sent to the interviewees.

The interview sample is not large enough to provide any generalized facts. However the interviews provided good insight into IO and DSHAs, but should not be treated as generalized facts. The interviews thus made it possible to provide some interpretations of current and future practice regarding DSHAs, which also is valuable for further research.

The interviews covered the following overall areas:
- Interpretation of IO
- DSHAs currently used by the company
- How the current DSHAs were used in the company
- How current DSHAs were communicated to company staff and contractors.
- How DSHAs were created and updated in the company.
- Whether the current DSHAs were considered to be well-adapted to an IO context
- Other issues

The interview guide can be found in the Appendix 1.

The main outcome of the interviews was summarized, and the summaries served as basis for interpretation of the results. When the interview study was considered to be completed, our interpretations were sent to contact persons in the petroleum companies and PSAN for commenting.

The interviews show that none of the studied companies presently had established DSHAs as a direct consequence of the IO development. For this reason, it seemed most reasonable to structure the reporting of the result under two general headings: DSHAs of today, and IO-related DSHAs.

4.2 DSHAs used Today

In addition to the DSHA-set from RNNP/PSAN (see page 12), we obtained seven sets of DSHAs during the interview study. Overall, the interviewees reported that the DSHA-sets were developed with reference to the traditional operational environment, and that IO had not been explicitly considered when the DSHAs were established and updated.

To obtain an indication of the extent to which the existing DSHAs were similar across the industry, six of the seven DSHA-sets obtained were documented in Table 3. The DSHA-set excluded had a structure that radically differed from the structures of the other DSHA-sets.
obtained. Since the excluded DSHA-set was based on analyses of existing DSHA-sets, we are confident that the DSHAs contained in the excluded set are adequately covered in Table 3.

As can be seen from the Table 3, the DSHA-sets are reported without specifying the name of the company to which they belong. This solution was chosen when one company informed that they for safety and security reasons did not wish that their DSHA-set was published with their name as identifier. Instead of using name as identifier, we characterize the type of DSHA sets reported: “Standard” generally refers to DSHA-sets aimed at offshore installations, but are in some cases extended with other types of DSHAs. “Onshore” to DSHA-sets aimed at onshore installations. “Dedicated” to DSHA-sets developed in relation to a dedicated task/function.

In Table 3, the DSHA-sets are loosely grouped depending on the type of risk addressed to facilitate comparisons, using the DSHA-set of RNNP/PSAN as a starting point (see section 2). In situations where PSAN did not have a comparable DSHA, the DSHA was added either in an empty row below what seemed to be the most similar type of occurrence, or in the first empty row of the table. This structuring is reasonable as the interviewees told that RNNP was an important input to their DSHA-set.
Table 3. The sets of DSHAs covered in the present study (except for one that was structured radically different) grouped depending on the type of risk addressed, using the DSHAs of PSAN’s RNNP project as a starting point.

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<td>Non-ignited hydrocarbon leaks.</td>
<td>Hydrocarbon leakage</td>
<td>Hydrocarbon leakage (flammable)</td>
<td>Hydrocarbon leak (including on fire)</td>
<td>Non-hydrocarbon fire at plant</td>
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<td>Ignited hydrocarbon leaks.</td>
<td>Loss of well control/blow out, including abnormal well state</td>
<td>Blow-out (including down hole situation)</td>
<td>Well problems</td>
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<tr>
<td>Well kicks/loss of well control.</td>
<td>Fire in auxiliary system/ auxiliary area</td>
<td>Fire in auxiliary system/ auxiliary area</td>
<td>Fire or explosion in furnace or transformer Fire in Admin.block Fire in substation Fire in condensate tanker at moorings Leak or fire on jetty Gas leak or fire in slug catcher area Gas leak or fire in process area Leak of hot oil</td>
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<td>Fire/explosion in other areas, flammable liquids.</td>
<td>Fire in living quarter</td>
<td>Fire in living quarters</td>
<td>Fire in construction barracks or site office huts</td>
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<td>Chemical spill</td>
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<td>Vessel on collision course.</td>
<td>Collision with vessel</td>
<td>Danger of collision by vessel out of control/drifting object.</td>
<td>Risk of collision</td>
<td>Ship adrift</td>
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<td>Drifting object.</td>
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<td>Collision with field-related vessel/installation/shuttle tanker.</td>
<td>Lack of buoyancy (not fixed installations)</td>
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<td></td>
<td>Loss of position (not fixed installations)</td>
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<td>Structural damage to platform/stability/anchoring/positioning failure.</td>
<td>Leaking from subsea production systems/pipelines/risers/flowlines/loading buoys/loading hoses.</td>
<td>Leakage from pipeline close to installation (not drilling rigs)</td>
<td>Pipeline emergency</td>
<td>Leak from pipeline near platform</td>
<td>Oil spill into sea</td>
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<td>Underwater leak</td>
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<td>Damage to subsea production equipment/pipeline systems/diving equipment caused by fishing gear.</td>
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<td>Evacuation</td>
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<tr>
<td>Helicopter occurrence.</td>
<td>Helicopter accident at the installation</td>
<td>Helicopter accident</td>
<td>Helicopter crash on platform</td>
<td>Helicopter incidents</td>
<td>Helicopter crash</td>
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<td>Helicopter accident at sea close to the installation</td>
<td>Helicopter accident in sea close to installations</td>
<td>Helicopter crash in sea near platform</td>
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<td>Man overboard</td>
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<td>Man overboard</td>
<td>Gangway collapse and/or unintentional disconnection</td>
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<td>Serious injury to personnel.</td>
<td>Acute medical emergency</td>
<td>Medical emergency</td>
<td>Acute medical emergency</td>
<td>Personal injury or illness</td>
<td>Medical emergency</td>
<td>Acute medical emergency</td>
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<td>Occupational illness.</td>
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<td>Occupational accident</td>
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<td>Epidemic</td>
<td>Abseiling accident</td>
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<td>Suspension accident</td>
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<td>Man overboard in the Moonpool inside the Jarlan wall</td>
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<td>GBS incident</td>
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<td>Total power failure.</td>
<td>Loss of power generation</td>
<td>Black out</td>
<td>Total electrical black out</td>
<td>Loss of power</td>
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<td>Control room out of service.</td>
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<td>Diving accident</td>
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<td>Heavy lifting operation out of control</td>
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<td>H²S emission</td>
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<td>Lost control of radioactive source.</td>
<td>Incident with radioactive source.</td>
<td>Radiation emergency</td>
<td>Accident with radioactive isotope</td>
<td>Radioactive isotope</td>
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<td>Falling object.</td>
<td>Dropped load</td>
<td>Dropped load in connection with lifting operations</td>
<td>Falling load</td>
<td>Dropped load in connection with lifting operations</td>
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<td>Acute pollution.</td>
<td>Acute leakage of dangerous material to sea or air</td>
<td>Accidental spill</td>
<td>Acute spill of hazardous substance into sea or air</td>
<td>Oil spill/Pollution</td>
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<td>Production halt.</td>
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<td>Transport system halt.</td>
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<td>Threats and criminal acts</td>
<td>Criminal acts, i.e., theft sabotage/terror</td>
<td>Threat of criminal attack</td>
<td>Terror attack</td>
<td>Criminal acts/Sabotage/Terror</td>
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<td>Unauthorized personnel</td>
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<td>Crude oil transport Norwegian water</td>
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<td>LNG vessel SS ARDIC LADY / substitute</td>
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<td>Extreme weather</td>
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<td>Emergency situations related to onshore activities</td>
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<td>Provisional DSHA for transitional phase during simultaneous operations</td>
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From Table 3 it can be seen that the three DSHAs sets of the type Standard are highly similar. Even though the level of specificity and the wording differ somewhat, these three DSHA-sets all include the following risks: hydrocarbon leaks, well kicks/loss of well control, fire/explosions, risk of collision with objects, pipeline leaks, helicopter events, man overboard, medical emergency, Incident with radioactive source, falling object, and accidental spills. For the other types of DSHA-sets, the differences are more pronounced. This reflects the fact that these DSHA-sets are developed with another key focus (i.e., onshore operation) or different types of dedicated tasks/functions.

The interviews provided detailed information about how the studied petroleum companies use, create, update, and communicate DSHAs. These issues are of key importance in the present study to contribute to a better understanding of the factors that may encourage or discourage considerations for IO-DSHAs.

**How are the DSHAs used?**

RNNP/PSAN and the studied petroleum companies use the DSHAs differently. RNNP/PSAN conceives DSHAs as risk indicators. They, e.g., calculate statistics with references to each DSHA, and use the results in assessments of the safety-level at the Norwegian Continental Shelf. The interviews indicate that for the petroleum companies, the DSHA-sets are a mean for ensuring emergency preparedness, in addition to using DSHAs as risk indicators. The emergency preparedness plans specify staff members’ roles and tasks during emergencies, and constitute the basis for training and emergency drills.

The fact that RNNP/PSAN and the studied petroleum companies use the DSHAs differently is, concretely reflected in the type of DSHAs which the companies - but not RNNP/PSAN – include in their DSHA-sets. Five of the six DSHA-sets from the petroleum companies, but not the DSHA-set of RNNP/PSAN, e.g. includes a DSHA that refers to criminal acts. Another example is the DSHA extreme whether, which is included in thee of the DSHA-sets.

The most likely reasons that RNNP/PSAN does not include the above type of DSHAs are either, 1) the events are too rare to provide the basis for statistics – this will in general also be true for installation-specific DSHAs, or 2) the events concern areas of responsibility beyond the authority of PSAN, such as, e.g., the Norwegian Pollution Control Authority.

Still, the reason why the petroleum organizations do include this type of DSHA is that should these situations occur they may turn out to have fatal consequences. For this reason, it is important that the companies are well-protected against, and have planned for and trained in handling of these – even if the events can be assumed to happen seldom.

**How are DSHA created and updated in the studied petroleum companies?**

The interviews show that DSHA-sets are created based on analyses of the risks associated with the operational activities addressed (see also section 2). Incident/Accident events that may imply loss of lives/health, damage to materials, and/or have negative impact on the environment are identified. When a given incident/accident event occurs, it will typically involve more than one of the above consequences. Important elements in the risk analyses are, e.g., analysis of constructions, assessment of work practices, clarification of different classes of danger zones at an installation, etc.

One interviewee stressed that not necessarily all DSHAs in a DSHA-set of the type Standard will be equally relevant on all installations of a company. Some of the DSHAs in set “B”, e.g.,
will not be relevant at an unmanned installation. As a consequence of the different risks associated with different installations and type of work, DSHA-sets may be created for each installation. Another interviewee, thus, reported that every individual installation, which his company operated, had to assess whether new DSHAs should be added to the Standard DSHA-set of the company. This procedure, he informed, was introduced to ensure that also all installation specific risks will be identified and addressed as part of the emergency preparedness.

One interviewee reported that two of the DSHAs contained on the DSHA list of his company mainly were mainly included to address/prevent damages to the company’s reputation. These DSHAs referred to situations in which suppliers/contractors transport goods for the company. The interviewee stressed that his company, as such, would hold no responsibility, should an incident/accident occur during the transportation. However, the company had assessed that should an incident/accident occur, they would still be involved, because it was their goods that were being transported.

The studied petroleum companies generally update their DSHA-set(s) when significant changes are introduced in the operational environment to which they refer. One interviewee reported that the DSHA-set of his company was going to be thoroughly updated when the company transited from drilling to production activities. Another interviewee underlined that changes in the regulations of PSAN might also lead to assessment of the need for updating DSHA-sets. DSHA-sets are revised based on analyses of the risks implied by the changes that initiated the revision process.

**How are DSHAs communicated to relevant parties, i.e. staff members and contractors/suppliers?**

The interviewees point out that the DSHAs are generally communicated to employees of the operator companies via the emergency preparedness plans, training sessions, and emergency drills. Offshore employees are often involved in the development of the emergency preparedness plans. These plans specify the allocation of responsibilities and tasks during an emergency, and constitute the basis for training sessions and emergency drills. In addition, communication may take place via other types of documents, such as brochures, which are distributed to the employees.

Another interviewee informed that not all contractor/supplier staffs working offshore were familiar with the DSHAs used at the installation, but that they were aware of the dangers at an installation in general. However, on onshore installations, contractor/supplier staffs working at the installation for a shorter period of time were not familiar with the DSHAs. For this reason, the contractor/supplier staffs would be given a guided tour when they arrived at an installation, focusing on general alarms, the muster alarm, safe work procedures, and would be shown the muster area. In general, the interviewees emphasized the importance of ensuring a good coordination with contractors/suppliers, which have their own DSHA-sets, to ensure that plans and adequate competence to fulfill the plans (i.e., training, drills) exist.
Overall Assessment

One of the interviewees made the following statement: “IO or not IO – the crises are the same. DSHAs are death and troubles that can strike an installation. The crises are the same, but the emergency handling is different in IO”

The quotation above illustrates neatly the main finding of the interviews when it comes to DSHAs in an IO-context. The interviews indicate that existing DSHAs are not influenced by the IO development. The data obtained during the interviews suggested that the essential reason why IO-DSHAs have not been developed in the industry is that the companies have not identified any new incident/accident events that may negatively impact humans, material, the environment (an/or reputation), in associated with the introduction of IO. Several of the interviewees stated that even though the introduction of IO implies a range of changes in what, how and where tasks are performed, it does not lead to significant change in the underlying physical processes. The present approach for developing DSHA-sets today implies that DSHAs constitute as top-events, i.e., they constitute events that imply or may directly lead to fatalities, damages, etc. When IO is introduced, the manner in which work is carried out at the installations, changes. Rather than impacting top events, these changes can be expected to impact the type of occurrences that constitute initiating events, i.e., the type of events that may precede the occurrence of a top-event. As long as DSHAs are developed from present perspective, i.e. that they are regarded as top-events, the introduction of IO may not necessarily come to impact the DSHAs used.

4.3 IO-related DSHAs

Not surprisingly, the interviewees had different interpretations of what IO is. The changes from traditional operation described by the operators vary between operators, installations and workplaces. It is thus difficult to give a distinct description of what IO imply for the industry today. However, it seems as the interviewees agree that IO will imply changes in work processes; integration of offshore and onshore operations; and better access to experts by use of multidisciplinary teams. An important contributing factor to these changes is the use of digital infrastructure, information technology systems and real time data.

The interviews indicated that “Lack of ICT-systems” can be a forthcoming IO-related DSHA. This DSHA can be broken down into:

- Lack of communication and information transfer offshore-onshore, e.g. cable rupture. However, there are satellite and radio systems that function as backup systems. Control systems can fail independent of IO, but one will have emergency backup systems for such failures as well. However, one can have a situation where everyone is evacuated from the installation – can one then control the installation from onshore?
- Incidents created by malicious acts (hacking, sabotage, virus infections). E.g. someone hacking into the SIS systems, taking control of the production and doing harm.
- Total power failure and total information drop out, both due to accidental events and malicious acts. One of the interviewees had experienced a total power failure in a control room during a drill, which lead to lack of information technology systems in the control room. The failure uncovered that there was no emergency generator at place, which was explained by a lacking check routine. The power was only away for a couple of seconds.

While the list of DSHAs remains unchanged, there are other IO-related changes that have considerable impact on the causal chains and what comes after the scenario (the consequence chains of the scenarios and the emergency handling). Inspired by the classical bow-tie model, Figure 3 shows how IO impacts DSHAs and related processes.
New technology and new work processes will impact the scenario’s causal chains. The new changes are mainly influencing basic causes, as the physical processes leading to the scenarios are mainly unchanged. However, new ways of communicating, digital infrastructure, new ways to organize work, etc. can be basic causes to unwanted incidents. When it comes to direct causes, one of the interviewees says that new technology can influence the probability of an incident, e.g. new drilling technology can influence the probability of occurrence by automation in the well and bottom-hole monitoring.

Input from risk analysis (QRA) (as described in NORSOK Z-013, see section 2) is one of the main factors contributing to updating and creation of DSHAs. New technology’s influence on probability has an effect on the QRA results, which furthermore impacts the emergency preparedness dimensioning. Today, the QRAs used as input to emergency preparedness analysis (EPA) are mainly based on experience data (frequency rates). It is too early to state whether IO will influence these frequency rates, but if IO changes the frequency rates one can also conclude that IO contributes to changes in the EPA results. Another interviewee questioned if increased complexity in work forms increases the probability of failures and human error, which further will influence the QRA and EPA results.

Most of the interviewees claimed that emergency handling and planning in IO is conservative. There are few changes in an “IO emergency preparedness” compared to existing emergency planning. Nevertheless, some new challenges and opportunities for emergency handling in IO are uncovered by the interviews:

- **1st and 2nd line of emergency resources.** Two of the interviewees said that IO will change the emergency organization, as parts of the 1st line of emergency resources will be moved from off to onshore.

- **Group mechanisms.** In a group that are located together to solve problems, there will always be a challenge related to the composition of the group and power mechanisms in the group. For example, over time groups will create ‘preferred solutions’ that can function well in some settings, and be inefficient in other settings. This can also be a challenge in the analysis phase – does the group identify the ‘correct’ problem? Another challenge is related to power mechanisms in the group – is it the most competent person or the person with most authority that is listened to in group-based decision-making processes?
- **Situational awareness.** IO provides more information about the crisis, which can 1) create an improved understanding of the situation and 2) give an improved overview of and allocation of resources at the 1st line of emergency. Based from emergency handling in traditional operation, one of the interviewees had experienced that it takes too much time to achieve the correct situational awareness. However, the same interviewee is not sure if the emergency organizations in IO is arranged to handle this information well. How to utilize the new decision support systems are not considered sufficiently. An example of such a tool is ‘Crisis manager’ which one of the studied companies uses in emergency handling. The software provides documents, checklists, logs and actions electronically instead of paper-based tools, which is particular helpful for 2nd line of emergency.

- **Power issues.** In emergency handling, hierarchical structures are necessary to provide an efficient and quick response. IO can contribute to this by improved and real-time data about the crisis and crisis handling. However, a challenge may arise as there might be many actors who have different opinions, which even can be ambiguous.

- **The transition from normal integrated operation to crisis handling** will be different than traditional operation. The interactions between actors will change, and new actors will be involved. One of the interviewees told about an ongoing discussion whether the operating room also should be the emergency handling room. The counterargument for such a design was that if you physically move from the collaboration room to the emergency room, you also change your operating mode. Change in mode is unlikely to happen if you are dealing with the crisis at your normal workplace. In emergency handling you also bring new people in with other operating mode and other functions than those working in the collaboration room. In can be challenging for new people being brought into the emergency handling to adjust to the working context of the collaboration room. This challenge is mainly related to 2nd line emergency resource.

- **Integration of contractors.** Emergency, training and DSHAs are traditionally being controlled by the operating company. When contractors, e.g. drillers, are more integrated into operations it will be required to think about new approaches. One of the interviews could tell about coordination and training together with a contractor.

- **Coordination of different actors.** One of the interviewees gave an example of how IO can contribute to an efficient emergency handling: coastal oil-spill preparedness. In such situations overview of resources and coordination of these becomes essential. There are many activities performed by different actors that have to coincide with each other. Many actors that are used to operate independent have to collaborate. As a result there is an extremely important requirement to coordinate resources. Many experts are brought in to handle the situation, which have to be coordinated without disturbing their activities. IO can contribute with tools that support this demand.

*This bulleted list creates to new challenges when it comes to training and emergency exercises in IO.*
5 Discussion of the Overall Results of the Study

The purpose of this study has been to describe requirements to and contents of DSHAs currently applied by the industry and to explore the demand for new or changed DSHAs related to the Integrated Operations (IO). Opportunities and challenges for use of DSHAs in an IO context were also explored.

The results from the interview study indicate that the industry views existing DSHAs just as valid in an IO setting as within traditional operation. Based on the interviews, it cannot be claimed that there is any impact on existing DSHAs by IO. The main reason for this is that the DSHAs are events that remain the same in IO as it is in traditional operations (e.g. a hydrocarbon leak occurring close to an ignition source is just as threatening in IO as in any other way we operate). As a result, the existing DSHAs are described at a level where the majority of IO changes are not visible. It is however important to note that the IO changes (for an overview of IO changes, see Grotan and Albrechtsen, 2008) are important contributing factors in creating the top event as well as the handling of the event.

The interviews indicate that the only aspect of IO that can produce a new DSHA is increased ICT dependency. This dependency creates new types of risk: lack of communication and information transfer between the production/operation site (normally offshore but also onshore) and the operation centre/support centre onshore; ICT-based SIS systems; and power and ICT failures in control rooms.

Although the findings in the interview study show a modest need for changes in the DSHAs, some literature in the field of IO research have argued for changes. Tveiten et al., (2008) state that the DSHAs of today are not adapted to IO. They emphasize that this may turn out to be critical, because it cannot be taken for granted that IO-related hazards are covered by the existing DSHAs – and, accordingly, that it cannot be taken for granted that all IO-related hazards are addressed in (emergency) training sessions. With the introduction of IO, it is at a minimum necessary to update the DSHA-based scenarios used in training programs to include the new groups of actors and systems, which are involved in virtual organization structures. This implies that DSHAs are more than sets of top events. They are used for dimensioning emergency teams; for emergency exercises; and for training in general. Also, they form basis for other sorts of planning, such as resources available on board/at site (spare parts, chemicals etc.). The need for changes in the use of the DSHAs is also claimed in this study. Some DSHAs are said to be relevant for the IO settings, such as the DSHA for oil spill close to shore which involves integration of many instances in emergency handling.

Lack of ICT systems is identified as a possible IO related DSHA by the interviews as well as the literature reviewed. This DSHA may include that expert evaluation/analysis for operation/well is not available in situation of deviance or in normal operation (that gets out of hand), and/or that there is limited contact between first and second line emergency team in an emergency situation (if first line emergency is still offshore) or that there is no local emergency expertise on installation if first line emergency has been moved onshore. It is explicitly suggested that an IO-related DSHA related to failure in ICT systems: “It is seen as a major risk that failure in ICT systems is not included in the usual DSHA analyses. When IO is applied, situations that involve a breakdown in the communication lines or other ICT related scenarios are relevant as DSHA-elements to ensure that these are taken into consideration in risk analyses, education, training, etc.” (Tveiten et al., 2008a, 16, our translation).
Although there is no influence on DSHAs as top events by the IO development, there are IO change elements that impact the contexts of DSHAs. As shown in Figure 4, IO has impact on the causal chains of DSHAs. For example, it is indicated by Tveiten et al. (2008a) that the maintenance level in IO will impact DSHAs. Although Øien and Schjølberg (2008) show that the IO maintenance development has been slow, Tveiten et al. (2008a) describes that it is expected that future IO maintenance will be based on long-term contracts such as integrated contractors/suppliers and that it will be a challenge to ensure adequate maintenance is such contexts. For example in situations where events occur, which requires activities that are beyond the normal/planned for activities (staff may e.g. not be available at the time).

The literature study in this report also indicates that other contextual factors changes in IO, which will have impact on the causal chains of DSHAs: new decision making processes; coordination and collaboration independent of location, organization and discipline; shared situational awareness; increased complexity and interactivity; information overload; new ways for communication; automation of normal operation; blurred responsibilities; new work organizations and teamwork.

![Figure 4. IO impact on DSHAs, causal chains and emergency handling](image)

The interviews indicate that the main changes in use of DSHAs seem to be related to the way deviances and emergencies are handled in an IO setting. Challenges related to: 1\(^{st}\) and 2\(^{nd}\) line of emergency resources; group mechanisms; situational awareness; power issues; the transition from normal integrated operation to crisis handling; integration of contractors; and coordination of different actors. These aspects create new challenges when it comes to training and emergency exercises in IO.

**DSHAs as indicators.**

Through RNNP the DSHAs are used as reactive indicators for the safety level in the industry. The number of events or accidents related to each DSHA are reported to the authorities. This
statistics can identify changes in IO may be picked up, though in a long term and maybe not before it is too late. This change is supported by other literature (see e.g. Mendonça, 2008) The Resilience engineering perspective argues for a proactive focus. It might be useful to consider whether RNNP or another reporting form can be adjusted to contain reports on deviations related to DSHAs so that it makes it possible to see trends in deviations in the industry as a whole and to compare installations based on the way they operate – e.g. look at typical IO operated installations and compare to others. This of course calls for criteria for what is an IO operated installation.

**DSHAs and risk analytical approaches**

Here we outline some of the basic steps involved in risk analysis, and emphasises how the DSHAs are included in such an approach. Most risk analyses starts with identification of some undesired event. The undesired event will be one of more events in the course of events leading to the accident. It is a challenge to both identify the undesired events, and to find an appropriate level for the analysis. In some presentations the word accidental event is used rather than the undesired event. The accidental event is often the first significant deviation from normal operation when we are focusing on loss of control over the energies involved with the accident. Examples of such accidental events would be “gas leakage”, “rupture of pipe containing oil”, “failure of gear box of helicopter” etc. To form a more comprehensive risk picture related to the undesired event a bow-tie like mental model is used where on the left side the causes for the event are developed, and on the right hand side the consequences given that the event occur are developed. A key element both in the causal analysis and the consequence analysis is the identification of safety barriers, and their performance. In some presentations we also use the term safety critical function (SCF) to include issues that are not directly “physical barriers”. These functions are similar to the root causes described in Figure 4. In a quantitative approach to risk analysis various types of models are used to link the performance of the SCFs to the total risk picture. Examples of such models are fault tree analysis, and event tree analysis.

The DSHAs applied in the RNNP project does not exactly match the concept of undesired events as often is the starting point for the risk analysis. One of the historical reasons for this is that the RNNP were aiming to find relevant risk indicators to measure trends in the risk level on the Norwegian continental shelf. It was then important to structure into “something which was measurable”. The result of this possess is the list in Table 2. We observe that some risk scenarios may include more than one DSHA in the conceptual bow tie model, for example “2- ignited hydrocarbon leaks” and “11 - evacuation”. Also note that to get an idea about the risk involved with the occurrence of one DSHA we need information about the SCFs (other barriers), both the structural relation between these, and their performance. For example fire and gas detection, emergency shut down system etc are not explicit listed together with the DSHAs.

During the work within the RNNP project it is believed that the DSHAs listed in Table 2 is a rather complete basis for spanning the risk picture. This is also confirmed with the present study, see Chapter 4.2. An intuitive argument is that the DSHAs in Table 2 represent those accident types we could imagine fairly well. A common critique against risk analysis is the

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7 A Safety Critical Function is defined as a function for which malfunction would immediately increase the risk of injury, or damage to health. Further we define a Primary Safety Critical Function as a Safety Critical Function intended to control the direct hazards related to the operation of the system being analyzed and we define a Secondary Safety Critical Function as functions to maintain and control the primary Safety Critical Function. (Vatn, 2006)
claim that risk analysis suffers from an adequate identification of what is often called “unexampled events”. However, in this study we do not believe that IO will lead to new accident types when it comes to the energies involved with the accident.

We will, however, expect that with the introduction of IO the interaction between safety critical functions and safety barriers might change. In future operation work processes etc may also change, thus new safety critical functions might be necessary to control root causes for DSHAs within IO.

In the risk analysis literature there is a huge number of methods and models which may be used to structure and analysis the performance of safety critical functions, the interaction between them, and how they relates to the risk picture. The barrier analysis model (Reason, 1997) was introduced as a conceptual model for understanding safety critical functions involved in organisational accidents. Dependencies and synergy effects between safety critical functions may to some extent be modelled by the common cause factor model, WPAM and similar models. However, in resent years the resilience engineering society has claimed that many accident scenarios will be “untractable”, and hence the structural way to model such scenarios will have weaknesses. Metaphors like functional resonance are introduced to shed light on issues not easy to include in existing models and methods.

**Change in theoretic understanding of safety – changes in DSHAs?**

DSHAs today are mainly the result of risk analysis, QRA, which is theoretically based on the energy – barrier perspective (Haddon, 1980) or to some extent models like the Swiss cheese model (Reason, 1990). It has been claimed that technical/quantitative risk analysis are not sufficient to capture novel, emergent and systemic risks, especially when the impact of human and organisational factors are brought into consideration (Hollnagel et al., 2006). The reason for this is that the established approaches assume that the systems they deal with are tractable. For that to be the case, four conditions must be fulfilled: (1) the principles of functioning must be known, (2) a system description does not contain too many details, (3) a system description can therefore be made relatively quickly, and that (4) the system does not change while the description is being made. It is thus interesting to consider whether other perspectives on safety can be used as a complementary addition to risk analysis, also when developing IO-DSHAs, since IO can fulfil the conditions mentioned above.

Perspectives such as High Reliability theory (LaPorte and Consolini, 1991) and normal accident theory (Perrow, 1984) as well as newer developments in non – linear understandings of cause and effect such as resilient engineering (Hollnagel et al., 2006) can be added as a complement to a risk-analytical approach and a energy-barrier perspective (Rosness et al., 2004). These perspectives will in most cases regard the same top event as hazardous as the traditional QRAs do, but the focus is shifted from the top event to what comes before the event – to the left side of the DSHA in Figure 4. An organisation that works according to HRO concepts\(^8\) will improve its ability to interpret and facilitate the transition from normal operation to emergency handling, thus improving planning of emergency handling not least if there are difficulties in transition for normal IO operation to IO emergency handling (which is indicated by the interview study). Other perspectives can enrich the understanding of how a DSHA is generated. Risk analysis in an resilience engineering perspective would aim at identifying functions in the system that vary in such a way that the system may become

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\(^8\) In later development of characteristics of an HRO five principles for safe operation have been developed: (1) Preoccupation with failure; (2) Reluctance to simplify; (3) Sensitivity to operation; (4) Commitment to resilience and (4) Deference to Expertise. (Weick and Sutcliffe 2001; Weick and Sutcliffe 2007)
unstable in given situations and then find barriers that can help damping the occurrence or effect of this variability. A DSHA in this coherence may then be descriptions of unstable situations that the system should avoid getting into because this will lead to hazardous events to emerge and/or a system that is unable to handle the hazard and bring the system back to safe state. If this sort of risk analysis is included, it will be an addition to the top events and probably increase the understanding of why and how the events occur even if they are known risks and planned for.

The information processing perspective (e.g. Turner, 1978) claims that accidents often occur when organizations do not perceive or ignore warnings and indications about an forthcoming accident, which are viewed as obvious in hindsight. The information processing barrier is thus concerned with the ability of an organization to make use of safety-related information, observations and ideas, independent of the locations or status of the person or group having such information, observations and ideas. This perspective is also highly relevant for IO DSHAs. Real-time data, monitoring and shared information should improve an organization’s ability to observe indicators of DSHAs in a proactive manner. This implies that attention is paid to the left side of the DSHA in Figure 4. By such perspectives, other aspects of risk and events can be identified, which the QRA can not identify. For the case of IO-DSHAs other perspectives is complementary to the QRA. However, this does not imply that the QRA should be turned down as input to the DSHAs.

5.1 Further Work

It as a paradox that the literature (e.g. OLF, 2007; Grøtan and Albrechtsen, 2008) on the one hand argues for new approaches to safety understanding while the findings in the interview study on the other hand indicates that few changes are carried out related to DSHAs and emergency handling. The main argument given for this is that emergency handling organisations are different than the normal organisations. First line emergency team size and structure is based on calculations or resource demand from risk analysis. The team members are members of the normal organisation. Changes in roles and responsibilities in the normal organisation may influence the emergency organisation. Another argument used is that the tools and equipment used in the operations are not advanced since they should be reliable in all situations. This means that collaboration technology, real time data, and involvement of external experts through virtual collaboration are not necessarily part of emergency handling. In such situations it may become a challenge to have a dramatically different way of operating and organising an emergency situation compared to normal operations. Though the reliability and user friendliness of technology is very important and should be part of any risk analysis of emergency handling plans, IO introduces changes that may be helpful in second line emergency management and in the internal collaboration between the emergency teams. This should at least be explored as opportunities for better emergency handling. The transformation from normal operation to handling of deviations and emergencies may even be critical and may introduce new risks if the adjustment to new work forms is not equal.

Proposed activities for further research on IO-DSHAs and emergency handling:
- To observe handling of DSHAs in an IO setting. These observations will be carried out at site(s) during emergency training or other activities when DSHA related scenarios are used.
- To study handling/closure of deviations in different operational settings. The purpose will be to look for differences between IO operated installations and traditionally operated installations.
- Create descriptions of the IO DSHAs as suggested in this report.
In addition to IO impacts on DSHAs and emergency handling, this study has indicated that IO influences the causal chains prior to DSHAs. As a result, the following aspects regarding safety barriers and safety functions are relevant for further research:

- **New** safety barriers/safety functions that have to be implemented for IO accident scenarios where the different DSHAs are involved.

- The *performance* of some safety barriers/safety functions are strongly affected by the introduction of IO.

- For some very “untractable” accident scenarios it can be expected that we are not able to express the relation between the introduction of IO and any explicit safety barrier/function. Furthermore, the relation between safety functions is rather complex and hard to treat with existing models and methods. In this case it would be necessary to look for new models and approaches beyond those methods existing today, e.g. Functional Resonance Analysis Method (FRAM) (Hollnagel, 2004)
6 Conclusion

Currently, the level of experiences with IO on the Norwegian continental shelf is rather limited, and it may be difficult to clearly envision new type of accidents/incidents that may be associated with IO. Thus, if the study is repeated in 2-3 years from now, the outcome may be different.

The outcomes of the interview study suggest that the industry does not currently see any need for generating specific IO-DSHAs. The exception is one or more ICT-related DSHAs. The chain of events that may lead to DSHAs changes when IO is introduced, as compared to in a traditional operational environment. This implies that the scenarios used for staff training should be revised, when IO is introduced.

The present study is exploratory in nature, and does not provide a final answer to the question of whether IO-DSHAs will be needed. For this reason, it is important to further explore the proposed new DSHAs presented in this report, as well as studying the build-up of emergencies and emergency handling in an IO environment. In terms of future research, we suggest than an observation study is carried out to uncover concrete changes related to the rise and handling of existing DSHAs in an IO environment, as compared to in a traditional operational environment. Identifying the concrete changes could contribute to further quality of the answer to the question of whether there is a need for IO-DSHAs. This type of study should pay particular attention to the possible relevance of the proposed new DSHA “failure/breakdown in ICT systems,” by assessing the consequences that failure/breakdown in ICT systems could have at different times, as the situation unfolds. In addition, comparing deviation logs between IO installations and traditional installations would provide concrete information about the extent to which the challenges faced in the two types of operational settings differ. Revision of training scenarios to accommodate changes in the chain of events leading to accidents is an issue of key concern. The suggested research approach would contribute to the basis for identifying the type of changes that need to be introduced in training scenarios and drills.
References


Ask, *personal communication*. Information provided by Rune Ask of DnV.


Haddon, W., 1980, "The Basic Strategies for Reducing Damage from Hazards of all Kinds." *Hazard Prevention* Sept/Oct

Johnsen, S.O., Ask, R., Røisli, R., 2007. “Reducing Risks in Oil and Gas Production Operations” Firs Annual IFIP WG 11.10 International Conference


Appendix 1: Interview Guide

The interviews will be semi-structured, and last around 2-3 hours each.

Introduction

1. The purpose of the interviews is to assess how DSHAs in the industry are influenced by the current and future development towards IO. It is thus important that the interview puts it emphasis on DSHAs and IO. In addition to this interview, we will perform 5 interviews of industrial partners in addition to Ptil.

2. Restate the information conveyed in the first mail: “Overall, the introduction of IO will change the work processes of the employees, as well as the companies’ infrastructure - including their communication technology. To contribute to ensure that the safety level at the Norwegian Continental Shelf will still be acceptable when IO is introduced on a large-scale, it is important to assess whether the present DSHAs adequately cover – and thus contribute to protect against - all hazards that may be associated with IO. (If this seems warranted: Are the chains of events that may lead to accidents different in an IO context, as compared to in a traditional context?) In other words, it has to be assessed whether there is a need for establishing IO-related DSHAs, and - if this is found to be the case - what events these indicators might refer to.”

3. Inform about the structure of the interview.

4. Stories about accidents and incidents that the interviewee reports/mentions to explain his/her perspective on DSHAs, will not be included in the report if the interviewee requires them to be left out.

5. Ask if we, if needed, may contact them later (identify one person) to clarify issues raised during the interview.

6. Ask if there are any questions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Topic</th>
<th>Question(s)</th>
<th>Activities / Comments</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Interpretation of IO</td>
<td>What do you perceive to be the major changes when moving from traditional operation to IO for your company?</td>
<td>General questions to obtain an understanding of how IO is perceived by the interviewee.</td>
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<tr>
<td></td>
<td></td>
<td>In what way do you think the “risk-image” for your company is changing when IO is introduced?</td>
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<tr>
<td>2a</td>
<td>If we have not received a list describing the DSHAs used in the company</td>
<td>What DSHAs are used in your company today?</td>
<td>Write down / Obtain the list.</td>
</tr>
<tr>
<td>2b</td>
<td>If we have received a list describing the DSHAs used in the company</td>
<td>This is the list… we have received – is this the DSHAs you are familiar with and that are used in your company?</td>
<td>Validate the list</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>How are existing DSHAs used in your company?</th>
<th>What are the main purpose(s) of the DSHAs in your company?</th>
<th>It could be, e.g., in risk assessments... training, emergency exercise</th>
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<td>4</td>
<td>Communication</td>
<td>How are DSHAs communicated in the organization?</td>
<td>Key words:</td>
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<td>Communication</td>
<td></td>
<td>- Formal-informal channels</td>
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<td>- Onshore – Offshore</td>
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<td>Communication</td>
<td></td>
<td>- In education and training</td>
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<td>How are the DSHAs communicated to contractors, etc.?</td>
<td></td>
<td>How are the DSHAs communicated to contractors, etc.?</td>
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<tr>
<td>5</td>
<td>How are DSHAs created and updated in your company?</td>
<td>How have the DSHAs you use today been defined?</td>
<td>Remember to ask how/if the creation or updating of DSHAs is impacted by Ptil, other petroleum companies, other organizations, etc. – both in terms of criteria and content.</td>
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<td>How have the DSHAs you use today been defined?</td>
<td>Remember to ask how/if the creation or updating of DSHAs is impacted by Ptil, other petroleum companies, other organizations, etc. – both in terms of criteria and content.</td>
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<td>6</td>
<td>Are the existing DSHAs well adapted to an IO-context?</td>
<td>Has your company adjusted the DSHAs or considered to adjust them to an IO-context?</td>
<td>Regarding each specific IO DSHA mentioned:</td>
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<td></td>
<td>Are the existing DSHAs well adapted to an IO-context?</td>
<td>Has your company adjusted the DSHAs or considered to adjust them to an IO-context?</td>
<td>Try to obtain clear and detailed information about the suggested DSHA:</td>
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<td></td>
<td>Are the existing DSHAs well adapted to an IO-context?</td>
<td>Has your company adjusted the DSHAs or considered to adjust them to an IO-context?</td>
<td>- The motivation for introducing the particular IO-DSHA.</td>
</tr>
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<td>Are the existing DSHAs well adapted to an IO-context?</td>
<td>Has your company adjusted the DSHAs or considered to adjust them to an IO-context?</td>
<td>- Examples on situations in which the DSHA could be critical.</td>
</tr>
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<td>Are the existing DSHAs well adapted to an IO-context?</td>
<td>Has your company adjusted the DSHAs or considered to adjust them to an IO-context?</td>
<td>- The particular content of the DSHA (try to relate this description to the criteria used for</td>
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<td>-</td>
<td>Regarding the specific DSHAs that need to be adjusted (if any), see questions in the right column.</td>
<td>defining DSHAs in the company</td>
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<td>-</td>
<td>What type of data that are required to determine whether the DSHA is/has been present (are these data automatically recorded today?).</td>
<td></td>
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<tr>
<td>7</td>
<td>Are there any other issues associated with DSHAs, which you find it would be relevant to mention here?</td>
<td>Key words: - integrated contractors - onshore vs. offshore - ?</td>
<td></td>
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<td></td>
<td>An open-ended question to obtain information about issues we have not thought about.</td>
<td></td>
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</tbody>
</table>