Decision making during critical incident among leaders offshore

Master Thesis

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Abstract

Work on board offshore drilling installations are hazardous, the personnel need to be vigilant in every part of the work in order to keep the risk level at a minimum. To have a critical incident, multiple barriers need to be broken, and that is what drill crews prevent on a daily basis. Critical incidents on an offshore installation, like a semisubmersible rig, can have disastrous outcomes to personnel, equipment and environment. We only have to look at the Piper Alpha, 1988 (Northsea). Alexander L. Kielland, 1980 (Northsea). Ocean Ranger, 1982 (North Atlantic) and Deepwater Horizon, 2010 (Gulf of Mexico), incidents to confirm this. In these accident a total of 285 people lost their lives, all rigs got totally destroyed, enormous financial losses and the environment took heavy damage from oil pollution. So what can be done to help prevent this? This study aim to build upon the results of (Martinsen, 2013; Øvergård, Sorensen, Martinsen, & Nazir, 2014). The purpose of this study was to identify characteristics of critical incidents and the characteristics of decision-making in offshore drilling. The targeted group is offshore drilling personnel. Semi-structured interviews were conducted with 14 persons that have a minimum of 10 years experience from drilling. The interviews provided 19 critical incident recollections and 9 incidents were dropped after the interviews. These were transcribed and thematically analyzed. Findings of this study include experienced adoption to operation characterized critical incidents in offshore drilling, routine complacency is a major contributor to incidents happening and some inconsistency to existing Endsley's three level SA model.

Keywords: Situation awareness, leaders, offshore industry, critical incidents

Introduction

Since early 1990's the oil and gas industry has continuously worked to increase safety and reduce accidents. These efforts has paid off, from 1990 to 2005 Norway has reduced offshore accidents by 20% (Authority, 2006). In most accidents in the industrial sector, there is causality between an organizations condition and the human errors (Turner & Pidgeon, 1997), and (Reason, 1990) indicates that human factors contribute as much as 70 to 80% of accidents in high risk industry. One way to reduce the number of accidents is to increase the offshore workers SA in operations on board (Endsley & Garland, 2000). Herein lies the ability to have an sufficient understanding of ongoing and upcoming operations, and to keep a high level of SA related to operations and the surrounding environment. The key point here is to understand how variables may change and to predict the outcome of multiple situational developments (Endsley, 1995a).

In many aspects this comes down to attention to tasks at hand and how this affects operations around. In cognitive psychology there has long been an interest in attention (Balota & Marsh, 2004), and the importance of attention to tasks with regards to accident prevention is well established (Paté-Cornell, 1993). In the industry the concept broadened to entail more than just attention, and the coined term is Situational Awareness (SA). There were a lot of different takes on SA in the early 1990 (Sarter & Woods, 1995); (Wiener, 1993); (Judge, 1992) and the concept was not properly defined or agreed upon. SA was mostly connected with aviation (Endsley & Garland, 2000). In 1995 Endsley proposed a starting point for a defined SA theory (Endsley, 1995b). This became a leading take on SA (Salmon et al., 2008) and guided a lot of the coming works that broadened the field of SA to include aircraft maintenance (Endsley & Robertson, 2000) and the military (Strater, Jones, & Endsley, 2001).

Critical incident into large scale disaster

Routine is what is used to describe activities that are done as a normal part of a job or process. It's when something happens to disturb the routine we need to react. The definition of a critical event is according to Flanagan (1954, p. 338) *'an incident is critical if it makes a 'significant' contribution, either positively or negatively to the general aim of the activity' and it should be capable of being critiqued or analyzed'*.

When a critical incident is not controlled it can escalate to a large scale disaster like the Deepwater Horizon accident in the Gulf of Mexico. This is what offshore personnel work towards each day with all the routines, procedures and checklists that are in place.

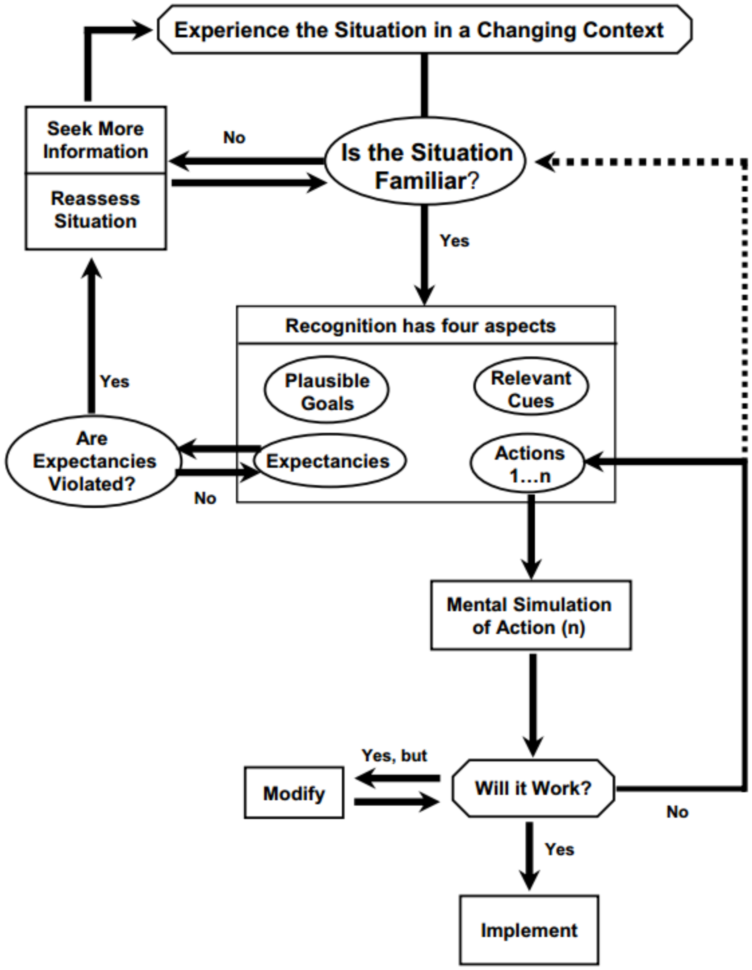
Situation awareness

Here is a brief description of Situational awareness (SA) as described by (Sneddon, Mearns, & Flin, 2006). The notion of SA has been in existence for many years, with references to the concept believed to originate from the pilot community of World War I. The most cited definition of SA is *"... the perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in the near future"* (Endsley, 1988, p. 792). SA involves concentration, attention to detail, and vigilance, which in turn create a sensitivity to cues in the environment signaling a change of state. (Sarter & Woods, 1991, p. 50) state that SA *"... is based on the integration of knowledge resulting from recurrent situation assessments,"* i.e. by continually appraising the situation and incorporating facts from it. The theory of SA draws upon the fundamentals of information processing, in that it is a cognitive process that involves the perception of information from the environment, and the amalgamation of this information with what is already known to form an understanding of the situation, all within the confines of the working memory (Smith & Hancock, 1995). The result is three levels of SA: perception, comprehension/information integration, and projection. Endsley's definition and triadic model (Endsley, 1995b) still dominate the field, and her model has been adopted here for analytical purposes.

Endsley parts SA into 3 levels where the first level of SA involving the perception of tasks and situational related cues in their immediate surroundings. To achieve the first level of SA one must perceive status, attributes and dynamics of the relevant elements in the environment. Attention is paid to the environmental cues that are relevant to the current situation in light of the actor's goals and experience in terms of mental models. The second level of SA involves whether one is able to understand the elements and their meaning. It involves whether one is able to understand the elements and their impact that they identified at SA level 1 in relation to the goal of the task. When one achieves the second level of SA, the participant develops a distinct understanding of the importance of the elements considered in the first level of SA. The participant now has full understanding of what each item means in the context of his or her situation and goals for the task. To get on the third level of SA one must be able to predict the future state of the elements of the environment. Using the information from SA level 1 and 2, as well as experience in terms of mental models, an participant predict or anticipate future conditions in the situation. For example, a driver anticipate that the car in front of him is going to brake sharply, as a result of that he has observed a queue in front of the car. Operators can effectively predict future events based on past experience and on the preceding level of SA. Endsley notes that experienced operators are better to achieve the 3rd level of SA as they use mental models shaped by experience with similar scenarios.

Recognition primed decision RPD

The decision process can be explained by two steps; situation assessment and selection of alternative actions. Recognition Primed decision (RPD) is widely used in NDM to explain decisions. Through analysis they have found that experienced decision makers in most cases make decisions once the problem is identified. These were experts in their field and generated only a single option. The choice was pulled out of different patterns that they had collected through both real and virtual experiences over many years. The alternative was evaluated by mentally simulating about it would work in this current situation. If the option seemed appropriate would it be conducted without a first compared this with other alternative. Only when not option could be adapted to an appropriate solution would decision makers envision next option (Kahneman & Klein, 2009). Those who are recognized within their profession to have the necessary qualities and skills to perform at the highest level within NDM are defined as experts (Kahneman & Klein, 2009). This definition may be somewhat vague, but is still satisfactory for most studies within NDM. Intuitive decision making is a strategy that separates the beginners from the experts. The expert has, unlike beginners, experience to recognize patterns, but also to identify when the situation is new for him and it is not appropriate to use intuitive decision making. One danger of intuitive decision strategy is that individuals sometimes make decisions that is successful by chance. These individuals will be prone to the illusion of skill and assertiveness. Later they will see themselves as experts and taking intuitive decisions deficient basis. They have more confidence in their own ratings than it actually is justified.



Figur 1 - Model of recognition-primed decision making. (Decision making in action: Models and methods. G. A. Klein, J. Orasanu, R. Calderwood, C. E. Zsambok, Editors. Copyright © 1993 by Ablex Publishing Corporation. Norwood, NJ. Adapted for use by Author.

Method

Sampling

This study used, to a degree a probabilistic sampling in the regards that the population sample could have been any randomly chosen fifteen drillers with experience offshore. The sample is a convenience, purposive, expert sample of the above mentioned group. The entire population was taken from the interviewer's working environment at a major international drilling company, which is as heterogeneous as any group of experienced offshore drillers in Norway can be. Drillers working offshore in Norway tend to move a lot around from rig to rig and from company to company therefore there was no need to sample a population from other parts of the industry. Subjects found other places in the North sea might just as well recall an incident from the same rig most population was taken from. There were negligible amounts of experts with foreign experience among the population.

Criteria's for the population.

The participants had to have at least 10 years of experience from offshore drilling, and at least 3 years of experience as "in the chair" drillers. All participants have worked their way up from deckhands to the current positions. 6 of the participants has experience from higher positions on board offshore drilling units. When approaching possible participants a couple of pre probe questions were used to pre eliminate candidates that did not meet the criteria's for the study. This was done for several reasons, among them to save time and not to needlessly disturb fellow workers.

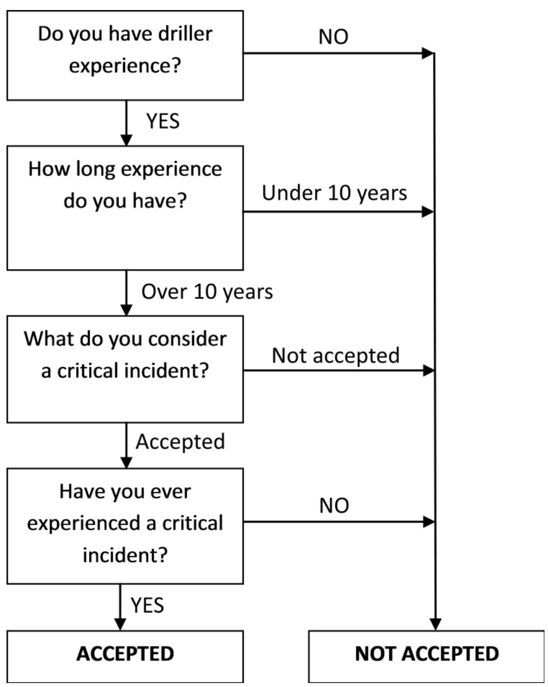


Figure 2 - Overview of sequential pre probe questions to approve candidates for participation.

Criteria's for including the incident.

The participants had to be directly involved in the incident, working as the "on shift" driller and responding to the incident to be admitted. Recollections of other incidents were excluded from the study. Some participants answered quite short to some of the questions, but were still admitted in the study. Only two incidents were recalled from the same rig.

Participants.

All participants in this study had at least 10 years of offshore experience, a minimum of 3 years working actively as drillers on an offshore drilling unit and recollected at least on incident where they had been working as primary point of action. All participants were considered professionals within the respective field of offshore drilling, ranging from proficient to experts (Ericsson, 2007). 39 Participants were considered for this study. 20 did not meet the probe question criteria due to lacking in either experience, incident of interest or time in driller positions. 4 qualified candidates declined to participate.

The final sample consisted of 15 candidates. All were interviewed between January and April 2015. The age ranged from 28 to 58 years (mean = 44,7; σ = 7,9). Offshore drilling experience ranged from 10 to 32 years (mean = 18,7; σ = 6,2). Experience as drillers ranged from 3 to 22 years (mean = 6,3; σ = 4,9). All except one participant had experience from both RAM rig and semi-submersible rig. Six participants had experience from higher position than driller. All except one participants had technical college, the highest education was technical college, the lowest degree was a 18 week course.

One interview were lost due to equipment problems, and the interview was deleted.

Critical incidents

During the interviews the participants described 19 number of critical incidents that were analyzed after transcription. 9 of the participants described only one incident the others described two.

Critical events are defined as events that are rare, uncertain with potentially high and broad consequences (Stewart & Bostrom, 2002). There will always be a limited opportunity for preparing and learning about them due to their rarity. They are also difficult to foresee and train for, only the handling of a broader set of events is possible to plan for. The risk in critical events encompass threats to life, environment or property.

Data collection

The data in this thesis is stems from interviews of offshore drilling personnel conducted to learn more about the characteristics of critical decision in drilling operation incidents. Semi-structured interviews that were based on a modified version of the critical incident technique (CIT) the critical decision method (CDM) collected data on drillers decision making during critical events. A demographic questionnaire collected data about the drillers expert characteristics.

Procedure

The author performed all the initial contact with candidates and collected all the data. If the candidate was accepted (See Criteria's for the population.) they were briefed about the reason for the interview and the objectives for the study. He, all accessible candidates to this study were male, were then asked if participation in this study were of interest. All except 4 of the accepted candidates chose to participate. For those who accepted to participate, a time and place for the interview were scheduled. Before the interview took place all participants were informed in more detail about the purpose of the study. General information about measures taken to guarantee confidentiality was also provided. Candidates were informed that participation in the study was voluntary and that the interviews would be used for research purposes. They were explained about the participants rights to withdraw their participation at any time up until a certain point, that after the transcription of the interview were done and the interview recording were deleted it was impossible for the researcher to erase their participation due to the anonymity of each participant. All were given an explanation about what their involvement would entail and their impact of the study results. The participant were explained that the interview were taking the form of an informal conversation, and that the interview would follow a mixed structure of critical incident technique and critical decision method, basically a retelling of a story with probe questions along the way. The nature and purpose of CTI and CDM were explained to all participants. All participants were presented with a demographic questionnaire. The questionnaire included 7 questions, determining sex, age, education and experience, offshore drilling experience and a brief description of various offshore drilling systems experience. The participants gave oral consent to the participation during the interview. Interviews were conducted at various locations of convenience, such as situation room, offices or drillers cabin. All locations were selected so participants were comfortable and felt at ease. Due to various circumstances some of the interviews were conducted at participants worksite during their working shift. This was requested by the participants themselves as not to do this during their "off watch" hours. The interviews lasted from half an hour to a little more than an hour. The interview structure made all participants feel at ease and enjoy the experience. This allowed for in-depth probing at places of interest during the interview. The fact that the author is an expert in offshore drilling and also work in this environment full time helps the probing during the interview and helps participants share more intimate details of the incidents than to non consecrated interviewee.

Critical decision method

Critical Decision Making (CDM) is a recollective method of interview that employs a set of cognitive probes to non-routine incidents that required expert understanding or decision making (Klein, Calderwood, & MacGregor, 1998). Like other cognitive task analysis methods CDM is intended to reveal information about human knowledge and thinking processes during decision making, particularly during non-routine decision making (Klein et al., 1998) in naturalistic decision making environment (Militello & Lim, 1995). The procedure of the method is to start by participant recalling an incident and describing it. The interviewee then recount the incident to ensure it has been understood properly. As the recalling is told the interviewee notes the decision points in the incident, disclosed via direct questioning. The questions utilized for this can be *"When did you first notice something was amiss?"*, *"Was there any pre warnings?"* or *"Who initially discovered the problem, and how?"*. The goal here is to identify the points where; (i) data were received or sensed, (ii) decisions were made or (iii) actions were taken (Mendonça, 2007). At this point the interviewee uses probe questions to deepen the understanding of the situation. During the interview it was used 13 reference questions, see

Table 1, to gather information about the characteristics of critical incidents and decision making in offshore drilling operations. The questions were used to be able to correlate with the results form (Martinsen, 2013).

Table 1 - CDM probe reference in interview questions

NR	*Probe type*	*Probe question*
Q1	Baseline reference	Can you describe a regular workday in drilling?
Q2	Baseline reference	What do you consider a critical incident?
Q3	Problem	What happened? Please describe.
Q4	Goal	What were you trying to achieve when this incident occurred?
Q5	Cue	How did you act?
Q6	Expectancy	Did you expect something to occur?
Q7	Situation awareness	Can you describe which information were available for you at the time?
Q8	Information integration	What was the most important piece of information available?
Q9	Uncertainty	Were you at any time uncertain about the reliability or relevance of the information available to you?
Q10	Conceptual	Could you have acted differently in this situation? Made a different decision?
Q11	Decision blocking	Was it at any point challenging to process the information available to you?
Q12	Recognition	In this incident, were you reminded of previous experiences, where a similar decision was made?
Q13	Recognition	In this incident, were you reminded of previous experiences, where a different decision was made?

For the interview itself it started with the participant describing their view of a regular workday, this was done to make a background reference. They were in question two asked to explain what a critical incident meant to them, this needed to be done in order to confirm that the incident they were about to describe actually were in the category of critical incident. Questions 3 to 13 were intertwined in the interview to gather detailed information about the incident, to be able to timeline decisions and be able to use the gathered data for analyzing critical incidents offshore.

Data Analysis

An exploratory thematic analysis were conducted on all interviews to organize the qualitative data in the interviews. It followed the four stages set by (Bryman, 2012). *Stage 1;*

Familiarize with the data, read the text as a whole, look for what it is about, find major themes, unusual issues, events and group together. *Stage 2;* Reread the text again, mark off key words and paragraphs, label for nodes, note any analytic ideas suggested. *Stage 3;* Code the text, systematically mark the text, indicate what chunks of text are and theme them, review the nodes, combine duplicates. *Stage 4;* Relate general ideas to the text, add own interpretation, identify significance for respondent, find interconnections between the nodes, relate nodes to research questions and research literature. All the data was also coded multiple times for different topics in mind.

Coding Software

The data collected in the interviews were analyzed using NVivo10 version 10.0.638.0 SP6 (64-bit). The use of NVivo greatly increased the abilities for coding multiple times on the same data, and after different topics. After the interviews were conducted they were listened to again to get a feel for the data. Then all interviews were transcribed, read and listened through and imported into NVivo10. In the software all interviews were coded in three different way. First they were coded open-minded, where the author coded any part with any node that seemed to be of interest. Then they were coded using preconceived theories of Situation Awareness (Endsley, 1995b) finally they were coded systematically where the nodes were generated based on the two other coding see example Figure 3.

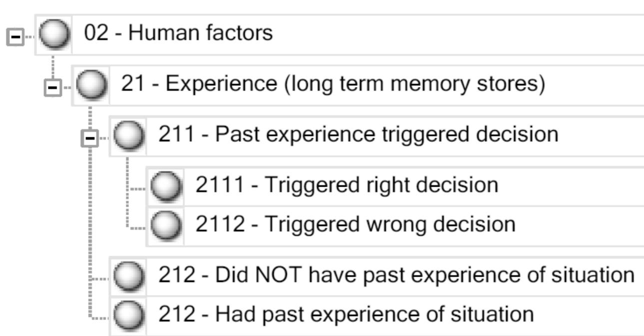


Figure 3 - Example extract of final node structure used on transcripts.

After the third coding additional coding runs were performed. This was done with regards to information gathering on select topics that came of interest later in the study. These include but do not limit to *"Description of critical events" "Themed statements" "Consequence hierarchy"* and *"Base event identification"*

Description of critical incidents.

Another main question during the interview Q2 was "What do you consider a critical incident?". This question resulted in 11 themes. The themes that only occurred once was discarded, that left 5 themes in this category (see Table 2).

Table 2 - Themes occurring in critical incident description

Theme	*Sources*	*References*
01 Endagering people	6	7
02 Damage equipment	4	5
03 Wellcontrol	4	5
04 Unexpected	3	3
05 Loss of barriers	2	2

The lack of consistent description of a critical incident may be a result of training offshore. Offshore personnel are constantly enrolled in courses offshore and onshore to be better able to cope with unexpected situations and to improve safety; Falck Nutec - Crisis management; Proactima - Investigation into unwanted incidents; UIS - Risk management; Ensure - Plan Do Check Act. A report (Kviseth & Øien, 2010) has this description:

> *"Level 1 - Comprehensive critical events: Events that have resulted in death, serious injury, very high contamination and / or significant damage to property.*
>
> *Level 2 - Critical events: Events with high loss potential (red incidents in Synergi).."*

Another description is from NORSOK S-006:

> *"Critical event: An incident which has caused or could have caused injury, illness and / or damage / loss of property, damage to the environment or third party (NORSOK S- 006)"*

NORSOK and PTIL is the two most prominent standardization institutions regarding the offshore industry in Norway and they have huge influence worldwide. When they can't be consistent with the descriptions then it's even more difficult for the persons far removed from the institutions themselves. One participants understanding of critical incidents comes close to the standards:

> *"Yes critical event that's when, uh it's, like, I immediately think, there are three types of critical incidents and it's kind of HSE related with people, personnel who may be injured. That is, uh, regarding equipment failure. and it is well-related events in terms of reservoir and inflow in the well and that type of thing."*

In this thesis we'll use this definition on critical incidents. Critical incidents are events that are unplanned, non-routine but do not end tragically yet have the potential to develop into large scale accidents. (Øvergård, Sorensen, Martinsen, & Nazir, 2015). All incidents related to in this thesis are based on this description to be included in the data.

Results

Characteristics of incidents

There were four characteristics of critical incidents that stood out from the dataset. This was not because every characteristic occurred in all incidents, but because they were central to all incidents they did occur in, the participants put emphasis on the them. Under the table will follow a short description of each characteristic with reference from the interviews.

Table 3 - Overview main findings for characteristics of critical incidents

Characteristics of Critical incident	*Sources*
Standard operation with small changes	13
Incidents often unexpected and difficult to anticipate	12
Usually small timeframe to comprehend and react to situation	10
Information lacking, wrong or misleading	9

Standard operation with small changes. A large portion of critical incidents offshore is a result of routine operations that have small alterations to them. The very unusual operations, like running a special tool or gravel packing almost never lead to an incident. In abnormal operations there is always performed Safe Job Analysis (SJA) and other incident preventative measures WRA, TOFS, on shore meeting, DOP and RAP. But in the routine operations, with small alterations, cues or elements can be ignored or forgotten. A lack of SA has been hypothesized to underlie the out of the loop performance decrement that can accompany automation (Carmody & Gluckman, 1993; Endsley, 1999). System operators working with routine tasks have been found to have a diminished ability to detect system errors and subsequently perform less on cognitive tasks in the face of routine failure as compared with non routine of the same task, for instance novices (Endsley, 1996, 1999; Godhavn, Pavlov, Kaasa, & Rolland, 2011; Kaber, Perry, & Segall, 2006). 16 of 19 incidents explained they conducted standard operations with small changes when incidents happened.

> *"I ran into the well with a fullbore tool and I got told to boost riser while I ran this here, and it was done. We boosted with 1000 liters per minute. I ran in and had the speed in which I normally use to have with the Tool there, and I got a few hundred meters into the riser then it was suddenly full stops and I crash into the topdrive... ...then we discuss a bit, and get hold of the person who owns the tool and when it gets explained it's all apparent, so it shows that this tool has a spring in it so when we land tool in the wellhead then it collapses a spring to seal off the tool completely tight. So when we get the explanation I understand immediately what has happened. When you get a head flow of 1000 liters per minute then this is enough that we collapses the spring, and then the tools seals up and gets stuck. This causes me to crash, then when then the resistance disappears in the form of the banana then the accumulated pressure presses the tool back in again."*

Incident often unexpected and difficult to anticipate. A lot of effort is used among offshore workers to be able to prevent incidents (Sneddon et al., 2006), and to prepare for any incidents that may occur. On a weekly HSE meeting on board there are safety alerts that are read out loud for the whole crew. These contain all the serious incidents that has happened in the last

6 weeks in the offshore industry. They describe the incident, underlying reasons for the incident, preventative measures and procedures to be implemented to avoid reoccurrence. In most companies all higher level personnel in drilling go through a bi yearly course in well control the International Well Control Forum (IWCF) course. This aims to give all higher level personnel offshore insight in the main operation on oil rigs - Drilling. The things that often lead to an incident is the unforeseen. This means nobody has thought of it, and it's very difficult to train for an event that is not thought of. There were only 2 out of 19 incidents that was anticipated, this means that 17 incidents came unexpected. Can the drilling companies train even more to be preventative. Here are a quote from the participants illustrating this.

> *"We ran in the hole with casing, suddenly we could not come further down. I tried a couple of times with no luck. Finally I tried to pull up, it was then evident that one of the segments on the slips had broken off. And with this PS30 slips the segments are below rotary. So as I pulled up one segment broke off and fell into the well, and that is critical. I should not have pulled up before securing that piece, but that is hindsight thinking, and that don't help."*

Usually small timeframe to comprehend and react to situation. The timeline from perception SA level 1 to projection SA level 3 and action can be very brief. This means that reaction and action should be drilled in advance to effectively and correctly react to situations (Klein, 1993). In the backbone of all the participants securing the well is primary and precede all other actions. And this is drilled so well among the drilling crew that the timeline for securing the well with a kellycock is usually below 60 seconds. 13 of 19 incidents reported small timeframe to make decision. This does not mean that there was an imminent danger if the decision was not meet, but there was a small timeframe to avoid an incident to occur.

> *"Pulled 3-4 more stands then we saw that this volume did not match, so we took a time out to clarify what could happen here now, since we had a good flow check. As we turned around to see what could happen, the fire came. Fast as hell. It just came, it was just.. the flame shot straight up into the air. I threw myself around and shut the well, and it was in the nick of time."*

"So I sat in the chair then, no I had compensator up then, that was it, well suddenly the DDM starts to creep and creep down pretty fast, so I try to run it on air as to bring it up again, and nothing happens and no matter what I do and try to run up the stick right? Then comes the DDM here only in fairly good speed down until the elevator just smashes in the slips, it smashes hard. It then turned out, when we looked for the fault, it was quite hard to find the reason there then. There was a valve that had something wrong with the inner parts."

Information lacking, wrong or misleading. The theory of SA draws upon the fundamentals of information processing, in that it is a cognitive process that involves the perception of information from the environment, and the amalgamation of this information with what is already known to form an understanding of the situation, all within the confines of the working memory (Smith & Hancock, 1995; Sneddon et al., 2006). The correct information beforehand or during an incident is paramount to making the right decision. 12 of the 19 incidents reported that they had lacking, wrong or misleading information prior to making a decision. This does not mean that this decision was used to make a wrong decisions, just that information of that caliber was available to the participant at the time of the incident.

"So I asked should I press the emergency stop now? Until we have the carrier in place? This was considered because when the emergency stop is activated the brakes clamp on more securely. What we did not know about this system here is that first the brake went off, and so on again with full force. So it fell 2meter the whole thing. 200 tons 2 meters, that shakes things up a bit."

Characteristics of decisions during critical incidents

During the interviews 8 themes stood out in describing the characteristics of decisions during critical incidents. Like the characteristics of critical incidents the author deduced the importance of these themes from the thematic analysis of the interviews, and found the importance of each theme due to the description from the participants. We'll look into some of them with reference to interviews in the next part of the thesis.

Table 4 - Overview main findings for characteristics of decisions during critical incidents

Characteristics of decisions during critical incident	*Sources*
Cues were sorted based on experience and information gathering	17
Imperative to secure most critical element first	16
Cardinal decision made on experience and instinct	10
Experienced projection of consequence determine action	11
Decision made as a team	7
Look for trends to detect changes that can predict outcome	6
Time out to figure out situation	5
Information prior to incident influenced decision	2

Cues were sorted based on experience and information gathering. The natural occurrence in SA is to first achieve Level 1 - perception in order to reach the higher levels (Endsley, 1995b). What was found in drilling is that the cues was not apparent during the initiation of the incident, they were gathered and sorted as a reaction to the incidents. 17 out of the 19 incidents were unexpected. And in most of the incidents the participant did not look up any procedure to make the decision, it was based on experience or cues or information gathered after the incident had initiated. 12 of the 19 incidents followed procedure during the incident, mostly that was because the experience guided actions within the procedure, they had been drilled enough on procedure that it was the natural choice during decision. Procedure was the experience. The participants reported directly thus, the last information was deducted from the transcript.

Table 5 - Overview decisions during critical incidents

Node number - Decision	*Sources*	*References*
242 - Decision made based on procedure	3	3
243 - Decision made based on experience	6	9
244 - Decision was trial and error	2	2
245 - Decision based on instinct	2	2

One participant described decision made from experience and information gathering like so:

> *"In this situation it started to blink in the emergency lights, then the alarm went off. There was no PA announcement so I called the control room to find out what was happening. Nothing they said. Then one roughneck said he smelled smoke. I stopped and told them to check the drawworks. It has happened before that some electrical wires on the drawworks have melted and caught fire. They did not find anything. Then the alarm went off again, the lights started flashing, and suddenly everything went black. Then there came a PA with information about a fire. Then we monitored the well with a guys using a flashlight into the rotary."*

Imperative to secure most critical element first. In 16 incidents, the first thought of all participants was to secure the well, either as monitoring or as intervention. Persons who are subject to advanced training show an increase in the number of new information elements that comprise their SA, an increase in the overall level of interconnectivity between those elements, an increase in the criticality of new and existing elements(Klein et al., 1998; Strater et al., 2001; Walker, Stanton, Kazi, Salmon, & Jenkins, 2009; Øvergård et al., 2014).

> *"I immediately think of the well, if the tool is sealed we do not have readings from the well, we do not have control of the well. Ehh, we open a failsafe, a valve below the BOP which provides communication with the well up another line than annulus and drill string, we then get readings from the wall and can confirm no abnormal pressures in the well."*

Decision made as a team. Much of the work on an offshore installation/rig requires teamwork. The successful attainment of the drilling task is entirely dependent upon the crew collectively working together, therefore team members must have a mutual understanding of the situation. In essence, the team should have a collective SA: this shared awareness is known as team SA (Baker, Day, & Salas, 2006; Endsley & Robertson, 2000; Salas & Cannon-Bowers, 2001; Shu & Furuta, 2005). Team SA can be characterized as follows: "process by which team recourses, activities and responses are organized to ensure that the tasks are integrated, synchronized and completed within established temporal constraints" (Day, Zaccaro, & Halpin, 2004) This shared knowledge and understanding of a given situation can then be called upon in order for the crew to make critical decisions and adapt, in order to react to and predict their working environment. Team SA is superior to single SA but it's imperative that each member has SA covering their respective part of the team or the team SA can be a hindrance (Endsley & Robertson, 2000; Gorman, Cooke, & Winner, 2006; Nofi, 2000; Salmon et al., 2008). In 7 of the 19 incidents the decision was made with help from the team, in one of the instances with a small timeframe to decide a supporting team member was present when the incident occurred. Whenever something happen on the drillfloor that impacts a timeframe of more than 15 minutes a higher level personnel is informed, thus most incidents will have impacts from multiple sources. The only exception to this rule is if the timeline from incident to consequence is too short for conference. One participant reported this team decision.

> *"I called the toolpusher, and he came up. We decided to get a roughneck to look into the well for mud levels. And we had some manual valves behind the doghouse that we could turn to get the string off bottom."*

Operations, consequences and base events.

The operations were first divided into 10 themes, as the analysis progressed it was natural to merge some of the themes. This process was done three times, it then emerged 4 different themed operations at the occurrence of the incidents, described further on as themes. These offshore drilling themes were; Tripping in/out of hole, Drilling, Down hole operations and Offline activity. Furthermore the incidents were divided into 5 categories of consequence and 5 categories of base events.

Table 6 - Overview themes and categories

Themes drilling operations	*Categories of consequence*	*Categories of base event*
Running in/out of hole with string	Death, lost rig & well	Lacked well-control
Drilling	Personnel injury	Lacked experience
Down hole operations	Lost well	Procedure not followed
Offline activity	Emergency disconnect	Human error
	Lost rig time	Equipment failure

All the resulting themes and categories were generated based on the participants interview and the situations leading up to the incidents. All themes are well established notions in the offshore drilling domain, and recognizable within the whole drilling industry. An overview with relationships between theme and categories can be seen in Table 7, Table 8 Table 9.

Table 7 - Relationship Between Type of Operation and Base Event

		Base event					Total
		Equipment failure	Lacked experience	Procedure not followed	Human error	Lacked well-control	
Type of operation	Tripping with string	4	0	0	4	3	11
	Drilling	0	0	0	1	4	5
	Down hole operations	0	1	0	0	1	2
	Offline activity	0	0	1	0	0	1
Total		4	1	1	5	8	19

A statistical cross tabulation analysis summarized the categories to provide a picture of the interrelation between the categories. The chi-square test showed a significant relationship between type of operations and bare event. ($\chi2$= 33.43, df = 12, p = .00083, see

Table 7) When looking at the numbers this is because of two incidents. There was only one incident containing Offline activity paired with Procedure not followed. This gives a boost in statistical significance. There is also only two incidents containing Down hole operations, whereas one of these was the only incident containing the Lack of experience. This will also contribute to a marked increase in statistical significance. If removing the Down hole activity and down hole operations from the analysis the chi-square gives $\chi2$ =4,297, df=2, p=.117 In the two other comparisons , between Type of operation and Incident consequence ($\chi2$ = 12,081, df = 12, p = .439, see Table 8); Base event and Incident consequence $\chi2$ = 16.86, df = 16, p = .395, see Table 9. The Chi Square test did not indicate any dependency between types of operation and base events or types of operation and consequence, as the results were to be considered non-significant.

Table 8 - Relationship Between Consequence of Incident and Types of Operation

		Consequence of incident					Total
		Lost rig time	Emergency disconnect	Lost well	Personnel injury	Death, lost rig & well	
Type of operation	Tripping with string	7	2	2	2	0	13
	Drilling	2	1	2	0	1	6
	Down hole operations	1	0	1	0	0	2
	Offline activity	0	0	0	1	0	1
Total		10	3	5	3	1	22

Table 9 - Relationship Between Base event and Consequence of Incident

		Consequence of incident					Total
		Lost rig time	Emergency disconnect	Lost well	Personnel injury	Death, lost rig & well	
Base event	Equipment failure	3	0	1	1	0	5
	Lacked experience	0	0	1	0	0	1
	Procedure not followed	0	0	0	1	0	1
	Human error	3	2	0	0	0	5
	Lacked well-control	3	1	3	1	1	9
Total		9	3	5	3	1	21

Results of the thematic analysis

During the total 14 interviews with the participant a thematic analysis of the 19 recalled critical incidents were organized into themes with sub themes. All in all the interviews were coded with a total of 996 nodes using 1849 references. During the open minded coding it was generated 111 unique nodes from two interviews. During coding of preconceived theories of Situation Awareness it was generated another 73 nodes. The author then merged many of the nodes into themes, this worked out as a mix of open minded and preconceived nodes. This generated 3 main themes with a total of 24 sub themes. The sub themes resulted in list with a total of 73 unique themes (see APPENDIX 5 - Overview mixed transcribed nodes).

Habitual day offshore. All participant got the same question during the interview. Q1 *"Can you describe a regular workday in drilling?"* From this question it emerged 12 themes, the themes that only occurred once in the interviews was discarded, so that 6 themes remained (see Table 10).

Table 10 - Themes in a habitual day offshore

Theme	*Sources*	*References*
01 Perception of upcoming operation	13	15
02 Handover	10	11
03 Team SA	8	10
04 Workload	7	9
05 Procedure	3	3
06 Learning	2	2

On participant described a normal day in offshore drilling like this:

> *"A normal day in drilling operations. It starts at 6:30 downstairs office. Where we have a quarter 20 minutes with handover and with something about the expectations that we are going face. Then it's some information from the crew that goes off so we are a little more prepared and informed about the hitch we go into. Then it's down to change and go to work, and try to be at work, well before at 0700. Then there is a handover at the workplace where we learn what has happened and what we should know to go through current operations . As soon as possible after we have had the handover we try to take a small meeting in the driller cabin on what we will do during the day with the guys working on the drill floor, so they know a bit the same things that we drillers do... and when we had that meeting we will discuss some procedures and stuff. And what we need to do then, also we proceed with the operation."*

Thematic analysis. During the thematic analysis of the 19 incidents recalled during the interviews 73 unique themes were found, this was merged into 24 sub themes and 3 main themes. The main themes that occurred during the coding was "Influencing factors", "Situation

Awareness", "Information". These 3 themes occurred in all 19 incidents, and are considered to be the main result of the thematic analysis. We will in the next sections look further into each main theme and some of the most important sub themes.

Table 11 - Overview main results of the thematic analysis

Main theme	*Total References*	*Sub theme*	*Sources*	*References*
Situation Awareness	215	Change in SA	14	59
		SA Level 2 - Comprehension	14	35
		SA Level 1 - Preception	14	32
		Decision	16	31
		SA Level 3 - Projection	14	26
		Team SA	11	18
		Expectations (preconceptions)	9	14
Influencing factors	142	Experience (long term memory stores)	14	39
		External factors	13	30
		Stress and Workload	6	15
		Performing actions	8	14
		Interface & system design	6	9
		Training	6	8
		Time	5	7
		Complexity	4	6
		Attention	4	4
		Automation	4	4
		Support	3	3
		Difficult to process information.	3	3
Information	123	Information	14	71
		Procedure	10	25
		After Action Review	7	15
		Handover	10	12

Situation Awareness. SA was the prominent theme in the findings. It was found that in the open minded analysis SA occurred adjusted almost as many times (open minded analysis of interview 1; 32 of 76 nodes = 42,1%) as in the final analysis (43 of 107 nodes = 40,1%). SA was referred to 215 times in 14 interviews. The participants reported that situation awareness was a key factor to be able to perform the work. Here is a statement by one participant regarding work offshore:

> *"I often find that I perform measures that one should not get a critical incident, we do all the time. That's what a lot of our work involves, control events so they do not become critical. That's is what risk assessment and risk management is. Proactive, we do it all the way. What could happen, what should we do, is this safe huh, what .. When we do it either way then. Alas, we are constantly thinking against critical events, but to prevent them then."*

SA is thought to work in levels. The first step in achieving SA is to perceive the status, attributes and dynamics of relevant elements in the environment - SA Level 1. Based on knowledge of Level 1 elements, particularly when put together to form patterns with the other elements (gestalt), the decision maker forms a holistic picture of the environment, comprehending the significance of objects and events - SA Level 2. The ability to project the future action of the elements in the environment, at least in the very near term, form the third and highest level of SA- SA Level 3 (Endsley, 1995b). What was found in this study did not follow these levels in all cases.

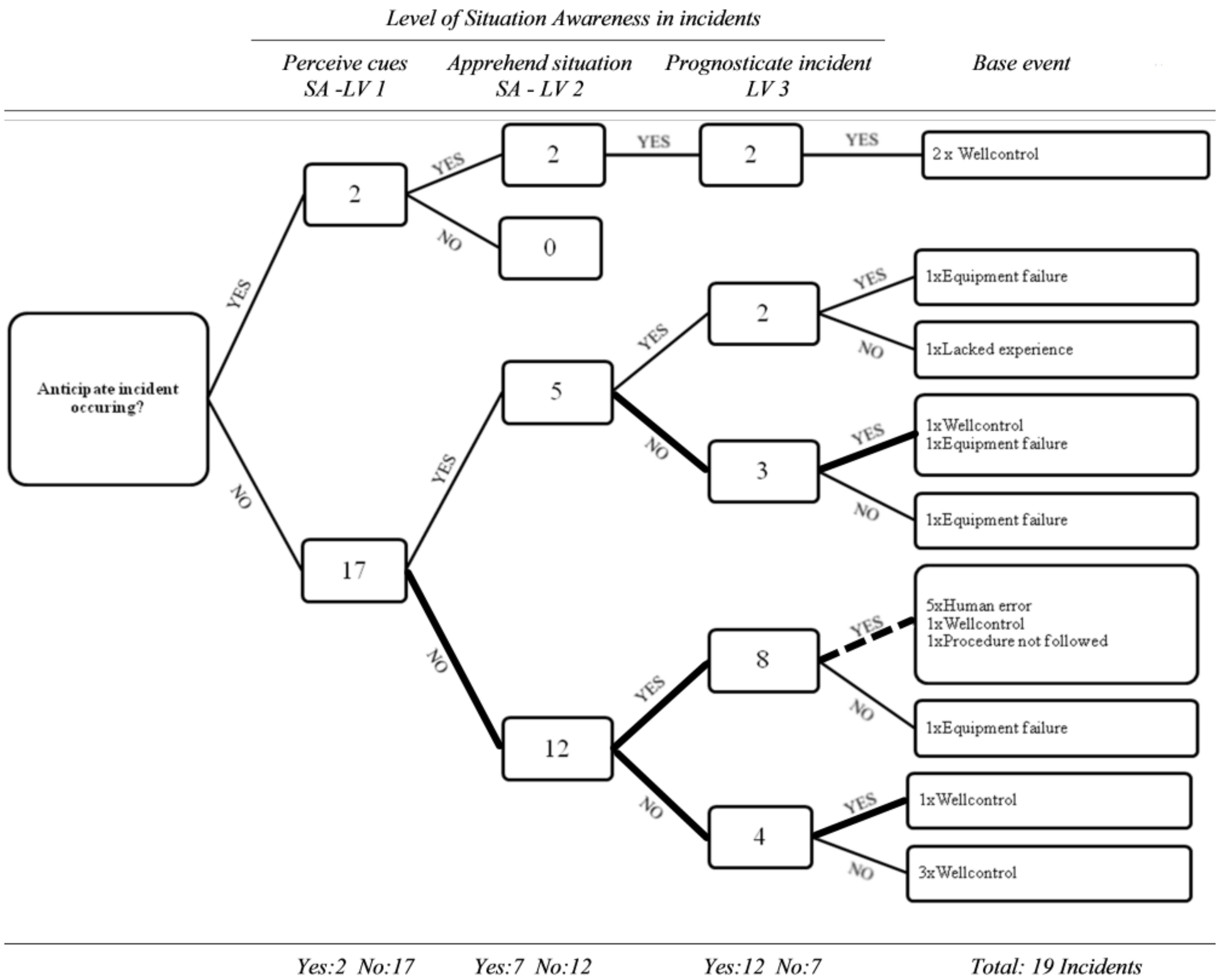


Figure 4 - Overview of SA level among participants during critical incidents.

In 17 of the incidents the participants did not anticipate the incident occurring. In the 2 incidents where participants did anticipate the outcome, they also went through the different SA levels as predicted (Endsley, 1995b; Judge, 1992; Salmon et al., 2008; Øvergård et al., 2015) following SA1, SA2 then SA3. Out of 12 participants that did not perceive the cues, did not reach SA Level 1, 8 continued to comprehend the situation, reach SA Level 2. That mean they comprehended the situation, and were able to react with that information as one of the guides, despite not perceive the cues in the situational elements. 7 of these participants were able to predict the future outcome of the critical incident. 3 participants were able to predict the outcome of the critical incident without apprehending the situation. In total in 13 of the incidents the participant were able to predict the final outcome and make appropriate decisions to prevent a major incident.

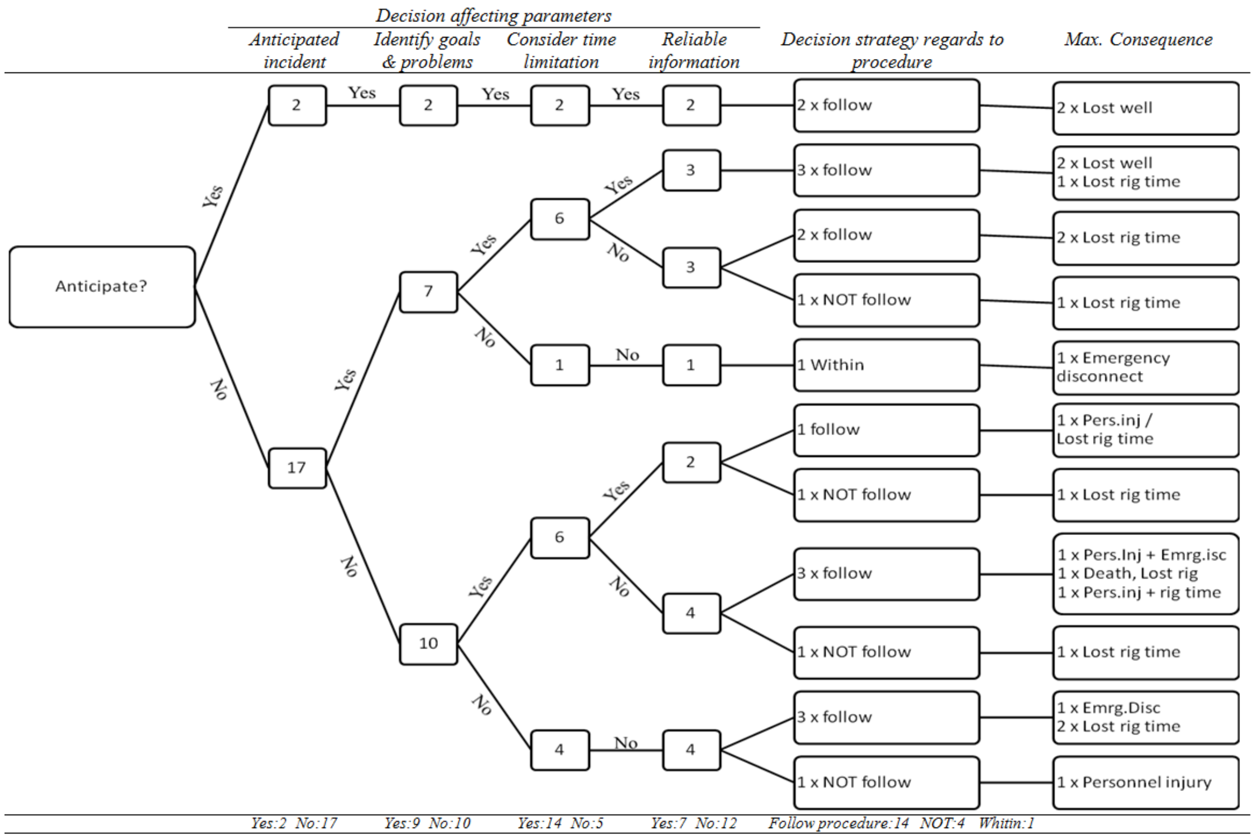


Figure 5 - Overview decision parameters and strategy

As we can deduce from this chart there were a majority of incidents that came unexpected. This is natural due to the fact that expected incidents usually are prevented, and don't reach a critical level. On the left there is a overview of what top level consequence could occur if incident is not controlled. 11 of 19 incidents reached their top level consequence; 1 lost well and 10 lost rig time did occur as a result of the critical incidents recollected by the participants. 3 out of 4 incidents where procedures were not followed reached top level consequence. 8 out of 14 incidents where procedures were followed reached top level consequence.

Discussion

The purpose for this study was to find out what characterized critical incidents offshore and what characterized the decisions made during a critical incident. One major finding in characterization of critical incidents were that most incidents happened because small alterations were done to routine tasks. Quote when asking if other information could have helped situation:

> *"No, this was something I had done many times before, and it was a standard operation and.... no."*

When small alterations are done, the task can be perceived as a routine task and SA is lowered accordingly (Endsley & Garland, 2000), when in fact SA should be higher due to the alteration. The work on the drillfloor is constantly changing from one type of operation to another. The work is very dynamic and parts of the operation is quite socio-technical, especially for the drillers. Despite this much of the operations are routine for the drillers and roughnecks. When operations and tasks become routine, workers tend to become complacent, this makes it more likely for accidents to happen (Perrow, 1994; Reason, 1990). There is supporting research for this in shipping (Hansen, Nielsen, & Frydenberg, 2002) where it was found that chances for accidents happening were higher during routine work than non routine work. Another supporting study (Kines, 2003), found that more SA Level 1 cues were perceived during non-routine work than routine work. When personnel conduct routine tasks they tend to lower SA, this is because the task is so "automatic" that changes takes less effort to detect cues. This is true as long as the task is exactly the same on all occasions, but in a dynamic environment as offshore drilling we should avoid lowering SA even during routine tasks. Changing persons performing the tasks and regular breaks can help keep SA high (Klein, Pliske, Crandall, & Woods, 2005). It is legitimate to propose that some participants in this study have been on "automatic" in routine operations when incidents occurred, not recognizing cues to their surroundings that may have helped in the situation. Another of the major findings in incident characteristics were that most of the incidents, 17 out of 19, were unexpected. The author recognize that this is the normal nature of incidents, and that if it was expected it could be dealt with. To be able to identify hazards earlier the offshore industry needs to look into additional training. The only way to expect the unexpected is to be aware that it's a possibility, and to do that one needs training. This is supported by (Walker et al., 2009, p. 686) who found that drivers who are subject to advanced driver training show an increase in the number of new information elements that comprise their SA, an increase in the overall level of interconnectivity between those elements, an increase in the criticality of new and existing elements, and an increase in favorable driving behaviors.

Lacking, misleading or wrong information was also a contributor to lowering SA during the incidents. In many cases there were information the participants stated they could have gathered beforehand. As stated by one participant:

> *I could always sought out the information, if I had though in those directions. For I knew well that when I landed this tool in the wellhead I collapsed a spring. It's just that I had not imagined that I could do the same with just the flow.*

Decisions during critical incidents were found to be taken much from experience. Much of the experience and skill of the participants coincided with procedures and thus their action were within procedures in the majority of incidents recollected for this study. Experience is one of the dominating factors in achieving high level of SA (Endsley & Garland, 2000), it provides a base to make a mental model that can be incorporated to predict future outcome. This is supported by (Doane, Sohn, & Jodlowski, 2004) who report that expert pilots are more successful in anticipating the future state of the flight. It is safe to assume that experienced drillers will be better at reaching SA level 3 and therefore have less incidents than less experienced drillers. Decisions made as a team were also prominent in the findings from the thematic analysis. In the biggest offshore drilling company in the world all incidents that take more than 15 minutes are reported live to a higher level personnel. Thus decisions regarding actions are likely to be conferred with others rater than alone. This also helps identifying cues and sort information correctly prior to taking action. In all incidents where the well was involved, the securing of the well was first priority. Therefore any action with that in mind were prioritized. This is due to a lot of drilling on this particular event, and further support the fact that training help SA during sudden changes in operation.

For further investigation it is recommended to look at routine operations. This is a contributor to critical incidents and should be taken into account when working in such a dynamic environment. A study into the sequential use of Endsley's SA model could also be of interest since this and at least one other independent study (Øvergård et al., 2015, p. 13) show a discrepancy in the model.

Conclusion

Sudden and unexpected changes in operation and experienced adoption to those changes characterized critical incidents in offshore drilling. In this dynamic and hazardous working environment the primary concern for all involved is the securing of the well during any incident. The huge amount of training in this regard help instinctive reactions towards that goal. Routine complacency is a major contributor to incidents happening, and steps to avoid routine automation should be considered by all involved in drilling operations. Decision making offshore is naturalistic and recognition primed and follow closely the known model (Klein, 1993). Some inconsistency with the sequential SA model (Endsley, 1995b) were found in the data. Participants achieved higher level SA in some cases without doing it consecutively.

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APPENDIX 1 - Demographic questioner

Demographic questioner				
Sex	Male		Female	
Age				
Do you have education within offshore drilling?	Yes		No	
How many years of experience in offshore drilling?				
How many years have you worked as a driller?				
Describe your education / certification:				
Describe your drilling experience. (type of rig, type of drilling systems, type of operations, your position on board, how many years on different rig types..)				

APPENDIX 2 - Interview questions

1. Can you describe a regular workday on Drillfloor

2. We are going to talk about critical incidents in this interview.
-*How do you define critical incident?*
-*Do you experience critical incidents often when doing operations on drillfloor?*
-*How often would you say critical incidents occur?*

3. Can you remember a critical incident?
- *What happened? Please describe.*

4. What were you trying to achieve when this incident occurred?

5. How did you act?
-*Which cues had influence on how you made your decision?*
-*How did you become aware that something was wrong?*
-*What were you looking for?*
-*Which information in your surroundings…?*
-*Which information did you use to reach your decision?*

6. Did you expect something to occur?
-*How did such expectations affect your decision?*

7. Can you describe which information were available for you at the time?
-*Did you use all available information?*
-*Can you think of other information which could have been useful?*

8. What was the most important piece of information available?

9. Were you at any time uncertain about the reliability or relevance of the information available to you?
-*Were you at any time uncertain about your decision?*

10. Could you have acted differently in this situation? Made a different decision?

11. Was it at any point challenging to process the information available to you?
-*How did it affect you?*

12. In this incident, were you reminded of previous experiences, where a similar decision was made?

13. In this incident, were you reminded of previous experiences, where a different decision was made?

APPENDIX 3 - Transcription of random interview

Intervjuer:

Så da begyner vi med 1, det er om du kan beskrive en vanlig dag med boring, når du sitter og borer. Det her kommer til å gjelde littegranne det å sitte å bore da.

Deltager:

det er det vi sikter oss litt inn på om du har noen hendelser rundt akkurat rundt boring, fordi det er veldig sammenlignbart med..

Deltager:

Boring eller brønn?

Intervjuer:

Ja brønn i og for seg, for det tripping, boring, det går litt på det samme med at man sitter å konsentrerer seg lenge også. Så.. Boring og brønn.

Deltager:

Ja, en vanlig dag som borer, da begynner man jo da med handover, møte i lag med de som har hvert på jobb. Typisk assisterende boresjef, og kunderepresentant før du går på skift. Ehh, der du går igjennom relevante ting som har skjedd i løpet av skiftet som har hvert, ehh du går igjennom det som du regner med skal skje på ditt eget skift, du belyser hvor risikoen er størst. Hva du skal ha spesiellt fokus på, den type ting. Så går du i drillerbua også får du da i tillegg handover av avtroppende person i samme stilling. Ehh, du snakker endel om rundt signaler som har blitt tolket, hvordan de har blitt tolket. Du gjør deg opp litt meninger selv rundt det som de har sett. Ehh, ja. ehh Så setter du deg i stolen og fortsetter operasjonen der som du har kommet. eeeh Du får de rundt deg til å gjøre de sjekken som du vil forsikre deg om at ting er som de skal være. Typisk opplining på choke, ehhh gjerne ta en runde på sirkulasjonssytemet, shaker og sånn. Se at alt er i orden. Ehhh, standpipe er linet riktig og sånn. Du kopierer ikke de som har hvert på sine oppysninger om alt nødvendigvis, du sjekker det selv for å hvite hva man har med å gjøre. Ja..

Intervjuer:

Det høres jo veldig ut som den normale dagen med boring det. Ehh, vi skal snakke om kritiske hendelser i intervjulet, og om du da har noen personlige erfaringer med det.

Deltager:

Ja.

[avbrutt intervju av tredjepart som trengte informasjon fra PA]

Intervjuer:

Ehhhh, så da er det egentlig, ehh, både kritiske hendelser som har skjedd og om det kunne ha skjedd på en måte. Om det er en eller annen hendelse som kommer og hvis den hadde utviklet seg så kunne det blitt en greie ut av det. Og om den har blitt avverget eller ikke og da er spørsmålet hva du legger i begrepet kritisk hendelse.

Deltager:

Ja kritisk hendelse det er jo da, ehh det er jo, sånn som jeg tenker umiddelbart så er det tre typer kritiske hendelser og det er jo type HMS relatert med folk, personnell som kan bli skadet. Det er, ehh, angående utstyr som kan feile. og det er brønn relaterte hendelser med tanke på reservoar og innstrømning i brønnen og den type ting.

Intervjuer:

Ehhh, når det gjelder brønn. Hva er det, er det noen kategorier med hendelser som går under kritisk da, som, ja det er vel i og for seg to ting, enten å miste mud i brønnen, eller å få.

Deltager:

Ja det er jo, det kan jo være kritisk i begge situasjoner, men det er jo først og fremst det å få noe inn i fra formasjonen som er, som er det vi normalt tenker mest på.

Intervjuer:

Ja, ehh opplever man ofte kritiske hendelser under boring?

Deltager:

Nei, jeg vil ikke si du opplever kritiske hendelser ofte. Det er, men det er ofte at du må eliminere en del signaler, du får, alt er jo basert på tolkning av signaler som du får ifra brønne og det er jo prosessene rundt hvordan ting blir vurder som kan eliminere en kritisk hendelse da, alså hvis man tolker signalene feil så kan man få en hendelse, tolker man det rett så kan man unngå en hendelse.

Intervjuer:

Ja, er det på alle de signalene man får som driller, er det veldig linket, eller er det veldig slått sammen med prosedyrer, eller er det erfaring som teller mest når man sitter å tolker signalene?

Deltager:

Ja, jeg vil jo, det er jo en kombinasjon selvfølgelig. Me jeg vil si at erfaring og, og ehhh, og, hmm kunnskap er jo det viktigste.

Intervjuer:

Ja. Hvor ofte vil du si at det oppstår kritiske hendelser ved boring? Har du et estimat der sånn? [Avbrutt PA melding]

Deltager:

Ehh, jeg vil si det er skjeldent, nå har vi veldig gode kunnskaper, kunnskap og ikke minst, ehhh, erfaring med, ehhh, for eksempel mud properties opp i mot de sorskjellige formasjonene, sånn at det er veldig skjeldent at vi har hull problemer. Mye skjeldenere enn før, og hull problemer i forbindelse med tap av sirkulasjon og avpakking og, stuck senario de blir skjeldenere og skjeldenere og det er jo ofte sånne situasjoner som kan lede til en mer alvorlig hendelse. Så jeg vil si at vi er i stand til å unngå brønnhendelse i mye større grad enn vi var før.

Intervjuer:

Ja, vi ligger jo et stykke forran enn i resten av verden.

Deltager:

Ja

Intervjuer:

Ja, jeg vil påstå det. Ehh da går vi over til det også beskrive en kritisk hendelse, hvis du har en kritisk hendelse du har hvert med på eller en nære kritisk hendelse som har blitt avverget, om du har en sånn.

Deltager:

Ja, jeg har sikkert flere om jeg hadde fått tenkt meg lengere om, men en som jeg har tenkt litt på i det siste, ikke minst fordi at vi har hatt en lignenede situasjon, det var jo når jeg var driller og jeg, vi skulle teste BOP. Ehh, jeg kjørte inn i brønnen med et fullbore tool [Dette er del av borestrengen som nesten har samme diameter som hullet vi kjører inn i] og det hadde full åpning, altså full flow pasasje. Ehhh. Sånn at du kunne kjøre relativt fort med det selv om det var fullbore tool. Rett før jeg begynte den trippen [utrykk for å låre borestrengen ned i hullet] der så fikk jeg et spørsmål eller en, ehh, at det var ønske om å booste riseren mens jeg kjørte in med dette her, og det ble gjort. Vi boostet med 1000 liter i minuttet. Jeg kjørte inn og hadd den hastigheten inn som jeg normalt pleide å ha med det toolet der, og, og jeg kom et par hundre meter inn i riseren så var det pluttselig bom stopp, og, og krasjer topdrive'en [maskineri som brukes til å låre og heise borestreng i hullet] i standet [stand er to eller tre borerør som er skrudd sammen før det låres i hullet, dette er hule rør med han gjenger i ene enden og hun gjenger i andre slik at de kan skris sammen. De er laget i ulike størrelser i stål. Alt fra 2 tommer til 8-10 tommer. Mest vanlig størrelse er 3,5 - 5 og 5,5 tommer], og bøyer det som en banan ut over V-døren [åpning i boretårnet som brukes til å hente ulike komponenter inn og ut via] ehhh, når jeg får stoppet så kommer standet opp igjen fra riseren og bare fortsetter og bygge på den bananen som allerede er. Alt blir svart for det er, ehh, mudden spruter fra toppen av pipen og og tar sikten vekk i fra alle vinduer. Forstår jo selvfølgelig ikke hva som skjer. Ehhh, ringer boresjef, han kommer opp og vi forstår fortsatt ikke hva som har skjedd. Jeg tenker umiddelbart på brønnen atte hvis nå toolet er tett så har vi ikke avlesning på brønnen, vi har ikke kontroll på brønnen. Ehh, vi åpner en failsafe [en ventil nede på BOP som gir kommunikasjon med brønnen opp en annen line enn anulus og borestreng. Blir bla. brukt til å kontrolere unormale trykk i brønnen. og får lest av på chokelinen vår atte de ikke er noen unormale trykk. Ehhh, ja så får vi diskutert en del og får tak i han som eier toolet og det viser deg at når han får forklart seg, så virker dette toolet som .. det er en fjær i det så når vi lander toolet i wellheaden så kolapser vi den fjæra og da blir det helt tett. Så når vi får den forklaringen så forstår jeg jo med en gang hva som har skjedd. Da har jeg i tillegg til at jeg kjører i normal hastighet som nok i utgangspunktet nok var helt i grenseland. Nåd du da i tillegg får motflow på 1000 liter i minuttet så er dette nok til at vi kolapser den fjæra, og da blir toolet helt tett. Ehh, erego så kræsjer jeg i standet og i tillegg så har jeg jo da akkumulert en del trykk under toolet, så når da motstanden forsvinner i form av den bananen så trykker det akkumulerte trykket toolet opp igjen.

Intervjuer:

Stempel

Deltager:

Stempel ja. Ja. det er jo en hendelse som både, altså man må tenke på brønnen, ehh, som sådan. Fordi at man ikke har kontroll på den. Det er jo en fare for personell siden du kræsjer, og røret som sagt kommer ut i V-døra og og i tillegg utstyr. Ehh, Så den hendelsen inneholder jo egentlig alle de tre elementene som jeg snakket kritiske hendelse og...

Intervjuer:

Ja definetivt. Var det åpent hull, var det utboret formasjon?

Deltager:

Jeg husker det ikke, men jeg regner med det, alså siden første tanken gikk på det at vi må få kontroll på brønnen. Så var det iallefall ikke en testet casing vi holdt på med for å si det sånn.

Intervjuer:

Nei. Ja, ehh. Med en gang det her skjedde. Ehh det er klart det er jo ikke så lett å huske bestanding når det er lenge siden. det er ikke så lett å huske rett etter hendelsen heller. Men, hvordan reagerte du, hvilke signaler er det du, hva er det du hadde, hva slags informasjon hadde du rundt deg.

Deltager:

I og med at årsaken var helt opplagt når virkemåten til toolet kom frem. Så er det klart at det første, ehhh, første tiltaket som ble gjort det var at i alle de kommende operasjonsprosedyrene som inneholdt det toolet så ble for det første anbefalt hastighet oppgitt, og at man måtte revurdere hastigheten om vi boostet riseren i tillegg. Så hadde jeg sittet med de opplysningen i utgangspunktet så , da hadde det jo ikke skjedd da.

Intervjuer:

Nei ikke sant. Ehh, Fikk du noe, det her skjer jo såpass fort at man rekker jo ikke å få noen informasjon fra skjermene rundt deg i det hele tatt

Deltager:

Ingen ting, nei ingen ting.

Intervjuer:

Du går jo bare rett i topdriven.

Deltager:

Det som er naturlig, når man først kollapser den fjæra der så, så er det sånn [knipser]

Intervjuer:

Ja, ehh. Så da har vi et par spørsmål her som egentlig går ut. Det er hvordan du ble klar over at noe var galt, og det var jo ikke så vanskelig å finne ut av.

Deltager:

Nei..

Intervjuer:

Når pipen står som en banan så er det ganske innlysende. he he he.

Deltager:

Ja, det er en god indikasjon på ikke alt er som det skal.

Intervjuer:

Ehhh, hvilken informasjon av det du hadde der brukte du for å ta din beslutning, jeg hørte du sa du åpnet failsafen også....

Deltager:

Ja men informasjonen som førte til at jeg forsto hva som hadde skjedd det var jo informasjonen om virkemåten til toolet. Med en gang jeg hørte det så var det opplagt.

Intervjuer:

Så hvis prosedyrene for det toolet hadde hvert annerledes så ville jo ikke det ha hvert en hendelse i det heltatt.

Deltager:

Og, og. I disse her, det som vi kaller RAP her da, det som de kaller DOP for Statoil og der har du jo risk elementer som er listet opp, det var heller ikke listet opp der som en risiko

Intervjuer:

I den kjøreprosedyren som man får for hver seksjon.

Deltager:

Ja på fremsiden der så står det jo, så står det risk elementer så..

Intervjuer:

Ja for det var jo ikke noen mulighet for å forvente at noe skulle skje her uten en sånn informasjon.

Deltager:

Nei.

Intervjuer:

Det er jo.. ehhh, Da har du egentlig belyst det neste spørsmålet om det var noen annen informasjon som kunne ha hjulpet, og det var det jo selvfølgelig hvis det toolet her.. Hvis det hadde skjedd med toolet tidligere og de hadde opplyst det så da hadde jo... Ehhh. Var du på noe tidspunkt usikker på pålitligheten eller relevansen av den informasjonen du fikk før det her.

Deltager:

Nei det der var noe jeg hadde gjort mange ganger før, og det var en standard operasjon og.. Nei. Forskjellen var at vi boostet denne gangen da. Ja. Den motflowen var..1000liter.. Ja, det kan du plusse på hastigheten så..

Intervjuer:

Ja for da får du jo.. Det er det samme som å kjøre enda fortere ned.

Deltager:

Ja, det blir dobbelt så fort det nesten ja.

Intervjuer:

Ehhh, kunne du ha, i det det skjedde, jeg vet ikke. Var det en drawworks, elmago eller var det på..

Deltager:

Nei, det var på en ramrig.

Intervjuer:

Ja så det var på ram ja, så det tar litt tid før han stopper, som vi har sett. Var det noe du, når du ser i ettertid, var det noe du kunne gjrt annerledes?

Deltager:

Jeg kunne jo oppsøkt informasjon, hadde jeg tenkt i de banene. For det er klart jeg visste jo at når jeg landed dette toolet i wellheaden så kollapset jeg en fjær. Det er bare at jeg hadde tenkt tanken at jeg kunne gjøre det samme med flow da.

Intervjuer:

Men var det noe du kunne gjort annerledes i det det skjedde, for jeg regner.. ehhh tipper her. Du slapp vel egentlig bare stikka da eller..

Deltager:

Ja, bare slapp.

Intervjuer:

Ja det er ikke så veldig mye annet man kan gjøre i en slik situasjon.

Deltager:

Nei.

Intervjuer:

For du får jo ikke stoppet

Deltager:

Nei, også får du jo på en måte testet deg selv litt. Altså, jeg fant jo ut om meg selv at om jeg havent ut i noe slikt så var jeg rolig og tenkte de rette tankene og var jo den som tenkte brønn med en gang og fikk monitorert på chokelinen og.. Ja du får en, en bekreftelse på at du håndterer noe sånt noe da. For å si det sånn, og det, den får du ikke før du har prøvd.

Intervjuer:

Det er.. Det er noen som sier at erfaring er en dårlig læremester, men innimellom så trengs den.

Deltager:

Ja den er en dyrbar eller dyrekjøpt lærdom, men det er ingenting man lærer mer av.

Intervjuer:

Nei.. Det er helt riktig. Ehh, ble du minnet på noen tidligere erfaringer hvor noe lingnende har skjedd?

Deltager:

Nei det var jo det vi utfordret leverandøren av toolet på, at det ikke var en anbefalt kjørehastighet, det var noe som vi fikk etterpå

Intervjuer:

Ja for det var jo...

Deltager:

Det kunne hvert unngått hvis de, hvis de hadde belyst den kjørehastigheten.

Intervjuer:

Da er det vel tenkelig at de egentlig ikke hadde hvert ute for problemet tidligere da, for da ville de vel kanskje ha.

Deltager:

Tja, det går jo ann å anta, da men, men vi har jo sett det før da at det er masse sånne oplysninger som som aldri når frem til all da.

Intervjuer:

Ja for det er, det med at det er 6 crew på en rig bare kan jo gjøre at man mister informasjon, og hvis det da er forskjellige rigger i tillegg så er det jo.

Deltager:

Ja, men hadde han tool eieren han er jo, var jo alene på riggen som hadde med det toolet å gjøre, så det er klart hadde han hatt informasjonen og ført den videre så kunne det jo været ungått. Det viser seg jo, når hendelsen skjer så får du de opplysningen som man hadde trengt

Intervjuer:

Ja, man får det etterpå... JA det er den gode gamle etterpåklokskapen. Ehh, ja for da faller jo den siste ut. Om det er en annen beslutning som ble tatt i en annen situasjon som var lignende. Ehh, har du. Det var veldig bra. Takk skal du ha. Det er jo, som du sa egentlig en hendelse som inneholder alle elementene på kritisk. Så den passer jo egnetlig veldig godt inn i det jeg trenger. Ehh, har du en annen som vi kunne gått igjennom også?

Deltager:

Nei, nå har jer ikke tid til mer.

Intervjuer:

He he he. Det er jo klart svar det. Det er veldig bra det.. Nok en gang tusen takk for at du ville delta. Det setter jeg veldig pris på.

APPENDIX 4 - Participant demographics

NR	*Date*	*Time*	*Interviewer*	*Transcriber*	*Length Interview (min)*	*Gender*	*Age*
01	07.03.2015	13:19	Michael Tjelle	Michael Tjelle	31	Male	44
02	07.03.2015	14:21	Michael Tjelle	Michael Tjelle	43	Male	40
03	09.03.2015	02:10	Michael Tjelle	Michael Tjelle	20	Male	50
04	10.03.2015	11:09	Michael Tjelle	Michael Tjelle	22	Male	48
05	20.03.2015	09:17	Michael Tjelle	Michael Tjelle	15	Male	50
06	20.03.2015	04:35	Michael Tjelle	Michael Tjelle	14	Male	58
07	09.04.2015	02:10	Michael Tjelle	Michael Tjelle	17	Male	41
08	09.04.2015	02:48	Michael Tjelle	Michael Tjelle	35	Male	28
09	10.04.2015	02:35	Michael Tjelle	Aurora Hylten	15	Male	38
10	11.04.2015	17:15	Michael Tjelle	Jeanine Desiree Lund	16	Male	46
11	10.04.2015	06:35	Michael Tjelle	Jeanine Desiree Lund	55	Male	44
12	14.04.2015	03:17	Michael Tjelle	Jeanine Desiree Lund	48	Male	47
13	17.04.2015	17:57	Michael Tjelle	Jeanine Desiree Lund	23	Male	46
14	20.04.2015	07:30	Michael Tjelle	Aurora Hylten	19	Male	34
15	20.04.2015	19:03	Michael Tjelle	Michael Tjelle	17	Male	57

NR	*Years in Drilling*	*Years as Driller*	*Educated in drilling*	*Education level*	*Education spesific*
01	14	7	Yes	Technical College	Teknisk fagskole boring
02	17	7	Yes	Technical College	Teknisk fagskole boring
03	19	3	Yes	Technical College	Teknisk fagskole boring
04	17	9	Yes	Technical College	Teknisk fagskole boring Teknisk fagskole maskin Trade certificate
05	24	9	Yes	Technical College	18 weeks drilling course Teknisk fagskole ongoing
06	32	22	Yes	Below college	18 Weeks drilling course, DCAP driller one week
07	20	5	Yes	Technical College	Teknisk fagskole boring
08	10	3	Yes	Technical College	Brønnteknikk Teknisk fagskole boring
09	14	4	Yes	Technical College	Teknisk fagskole boring
10	17	3	Yes	Technical College	Teknisk fagskole boring
11	17	9	Yes	Technical College	Teknisk fagskole boring
12	22	4	Yes	Technical College	Teknisk fagskole boring
13	16	4	Yes	Technical College	Teknisk fagskole boring
14	12	3	Yes	Technical College	Teknisk fagskole boring
15	30	3	Yes	Technical College	Teknisk fagskole boring

NR	*IADC course*	*Experience spesific*	*Years RAM rig*	*Years Conventinal semisub*
01	Yes	4 years TO winner, semisub; 3 years TO Barents, semisub RAMRIG	3,0	4,0
02	Yes	3,5 years semisub exploration drillig, completion 3,5 years RAM rig exploration drilling, completion	3,5	3,5
03	Yes	RAM rig, semisubmersible. Drilling and completion	0,0	3,0
04	Yes	Drillship 8y; Plattform 4y; Semisubmersble 17y; Jackup 1y; RAM rig 11y	11,0	17,0
05	Yes	Semi-submersible 6y; Safetycoach statoil 1y; RAM rig 3y	3,0	6,0
06	Yes	Semi-submerible. Ross rig, Ross isle, Southern explorer, Wildcat, Polar Pioneer, TO Arctic	0,0	22,0
07	Yes	Semi-submerible 3y RAM rig 2y	2,0	3,0
08	Yes	Semi-submerible TO Barents MH equipment, drilling and completion; Semi-submerible 6y Jackup 4y	3,0	0,0
09	Yes	RAM rig 8y; Semi-sub 5y; Drillship 1y	4,0	0,0
10	Yes	Semisubmersible; RAM rig	3,0	0,0
11	Yes	Semi-submersible, NOV, Cyber, Drillview, MH All operations; Driller 1; Mostly RAM rig	8,0	1,0
12	Yes	Semisubmersible; RAM rig	0,0	4,0
13	Yes	Semi-submersible; Plattform; Drillview, every operations, Driller; Semi-submersible 5y Plattform 11y	5,0	0,0
14	Yes	RAM rig 6,5y Semisubmersible 5y	3,0	0,0
15	Yes	RAM rig completion; Semisub 12y RAM rig 18y; All positions drilling	3,0	0,0

APPENDIX 5 - Overview mixed transcribed nodes

Name	*Sources*	*References*
01 - Situation Awareness	14	153
11 - Change in SA	14	59
Level 2 - Comprehension of current situation	14	35
122 - Negative	10	18
121 - Positive	10	17
Level 1 - Perception of elements in current situation	14	32
111 - Positive	12	17
112 - Negative	9	10
113 - Elements	3	5
Level 3 - Projection of future status	14	26
131 - Positive	13	21
132 - Negative	5	5
02 - Human factors	14	108
21 - Experience (long term memory stores)	13	39
212 - Had past experience of situation	9	12
213 - Did NOT have past experience of situation	7	12
211 - Past experience triggered decision	5	11
2111 - Triggered right decision	5	8
2112 - Triggered wrong decision	2	3
214 - Lacked experience	1	3
251 - Experience most important skill	1	1
24 - Decision	13	31
243 - Decision made based on experience	6	9
246 - Hindsight could have done differently	6	9
247 - Hindsight could NOT have done differently	4	4
242 - Decision made based on procedure	3	3
241 - No time to react to situation	2	2
244 - Decision was trial and error	2	2
245 - Decision based on instinct	2	2
26 - Expectations (preconceptions)	10	15
263 - Lack of Expectations (did NOT expect incident)	8	9
261 - Correct expectations (did expect something to happen)	3	4
262 - Wrong expectations	2	2
25 - Performing actions	8	13
251 - Action helped situation	5	7
252 - Action did NOT help situation	4	6
23 - Training	6	8
231 - Sufficient training	3	4
232 - Lack of traning	2	2
233 - Get training on possible critical incidents	1	2
22 - Abilities	2	2
221 - Sufficient abilities	2	2
222 - Lack of abilities	0	0

07 - Description	14	96
75 - Type of critical event	14	30
INCIDENT NOT APLICABLE	6	9
75 01b - Crane accident	1	1
75 01 - Blackout due to fire - HUMAN ERROR - Emergency disconnect	1	3
75 13 - Kick - WELLCONTROL - Lost rig, well, death	1	1
75 12a - Dropped piece of slips in hole - EQUIPMENT FAILURE - Lost rig time	1	1
75 12b - Dropped casing in hole, slips broke - EQUIPMENT FAILURE - Lost well	1	1
75 02 - Blackout due to wrong handling of equipment - HUMAN ERROR - Emergency disconnect	1	1
75 03 - Downhole RIH fast with fullbore tool - WELLCONTROL - Personnel injury _ Emergency disconnect	1	1
75 11 - Operating on DDM with personnel in area - PROCEDURE NOT FOLLOWED - Personnel injury	1	1
75 14 - Crash topdrive - HUMAN ERROR - Lost rig time	1	1
75 15 - Stuck casing hanger - WELLCONTROL - Lost rig time	1	1
75 15b Solenoid failure RAMrig - EQUIPMENT FAILURE - Lost rig time	1	1
75 14b - Wrong operation of compensator - LACKED EXPERIENCE - Lost well	1	1
75 02b - Stuck with liner in BOP - WELLCONTROL - Lost rig time	1	1
75 05 - Stuck due to packoff - WELLCONTROL - Lost well	1	1
75 09 - Lost string due to wrong operation slips - HUMAN ERROR - Lost rig time	1	1
75 10 - Crash with string due to tally error - HUMAN ERROR - Lost rig time	1	1
75 08 - Shallow water flow - WELLCONTROL - Lost well	1	1
75 07 - Stuck lose top hole - WELLCONTROL - Lost well	1	1
75 07b - Break fail on drawworks - EQUIPMENT FAILURE - Lost rig time_Personell injury	1	1
75 06 - Pump out casing - WELLCONTROL - Lost rig time	1	1
73 - Goal of the operation during accident	14	19
73 13 - Backream after drilling - DRILLING	1	1
73 12 - Run in hole with casing - RIH_POOH	1	1
73 11 - Clean and tidy - OFFLINE ACTIVITY	1	1
73 14 - Tripping out of hole - RIH_POOH	1	1
73 14b - Sementing conductor - DOWN HOLE OPERATION	1	1
73 15 - Cementing - DOWN HOLE OPERATION	1	1
73 15b - Run casing - RIH_POOH	1	1
73 01 - Pulling core - RIH_POOH	1	1
73 02 - Drilling - DRILLING	1	1
73 02b - Running in hole with liner - RIH_POOH	1	1
73 05 - Pulling out after drilling - RIH_POOH	1	1
73 09 - RIH with BHA - RIH_POOH	1	1
73 03 - RIH to test BOP - RIH_POOH	1	1
73 12b - RIH casing - RIH_POOH	1	1
73 10 - RIH for logging - RIH_POOH	1	1
73 08 - Drilling 26in hole - DRILLING	1	1
73 07 - Drilling 26in section - DRILLING	1	1
73 07b - Running BOP on riser - RIH_POOH	1	1
73 06 - Drilling out shoe - DRILLING	1	1
72 - Definition of critical event	14	15

71 - Normal day in drilling	14	14
74 - How often critical incident occur	14	14
76 - Personal feeling	3	4
762 - Negative	1	1
76 01 - Feeling unsafe	1	1
76 02 - Boring	1	1
763 - Feeling guilty	1	1
04 - Affecting Situation Awareness	14	83
48 - Team SA	11	18
481 - Positive	10	13
482 - Negative	5	5
44 - Stress and Workload	6	15
444 - Negative work situation	4	7
442 - Negative	3	3
443 - Night hitch	2	3
441 - Positive	2	2
43 - Interface & system design	7	12
431 - Positive	5	6
432 - Negative	5	5
434 - Not interpeted correctly	1	1
46 - System capability	7	9
462 - Negative	5	6
461 - Positive	3	3
47 - Time	6	9
471 - Enough time	4	4
472 - Not enough time	2	3
473 - How long ago incident happened	1	2
42 - Complexity	5	7
422 - Negative	5	7
421 - Positive	0	0
49 - Attention	4	6
492 - Difficult to keep attention	3	4
491 - Easy to keep attention	2	2
41 - Automation	4	4
412 - Negative	4	4
411 - Positive	0	0
45 - Support	3	3
451 - Positive	2	2
452 - Negative	1	1
05 - Information	14	71
56 - Procedure	11	25
561 - Procedure followed	6	8
563 - Procedure not available or valid	6	8
562 - Procedure NOT followed	3	5
564 - Procedure avaliable	2	4
51 - Enough information	12	15
55 - Not enough information	6	8

52 - Right information	4	5
54 - Too much information	4	4
51a - Confident about information	4	4
51b - Unsure about information	4	4
58 - Difficult to process information.	3	3
581 - NOT difficult to process information	2	2
582 - Difficult to process information	1	1
53 - Wrong information	2	2
57 - False alarm	1	1
03 - External factors	14	28
31 - Goals and Objectives	10	14
311 - Clear Goals and Objectives	9	12
312 - Unclear goals and objectives	2	2
33 - Handover	11	12
331 - Handover present	11	12
332 - Handover not avaliable	0	0
32 - Changed Goals and Objectives	1	1
34 - Equipment failure	1	1
341 - Emergency equipment faliure	3	4
06 - After Action Review	7	14
62 - Hindsight information that could prevented situation	6	9
63 - Using story to explain situation	3	3
61 - Actions was taken to prevent reoccurrence	2	2
TOTAL OCCURANCE IN ALL INTERVEWS	720	1512

APPENDIX 6 - Node overview Situation Awareness coding

Situation awareness

Name	Sources	References
01 Anticipate incident occuring	14	19
No	13	17
02 Perceive cues LV 1	0	0
No	12	12
03 Apprehend situation LV 2	0	0
No	4	4
04 Prognosticate incident LV 3	0	0
No	3	3
03 - RIH too fast with fullboretool -	1	1
05 - Stuck due to packoff - Wellco	1	1
06 - Pump out casing - Wellcontro	1	1
Yes	1	1
13 - Swab in kick - Wellcontrol	1	1
Yes	8	8
04 Prognosticate incident LV 3	0	0
No	1	1
07b - Break fail on drawworks - E	1	1
Yes	7	7
01 - Fire with blackout - Human er	1	1
02 - Short circut wirh blackout - H	1	1
09 - Wrong use of equipment - Hu	1	1
10 - Crash with string tally - Huma	1	1
11 - Use equipment danger for pe	1	1
14 - Lower DDM too fast - Human	1	1
15 - Stuck casing without compen	1	1
Yes	4	5
03 Apprehend situation LV 2	0	0
No	3	3
04 Prognosticate incident LV 3	0	0
No	1	1
15b - RAM chrashed on drillfloor -	1	1
Yes	2	2
02b - Stuck with casing - Wellcont	1	1
12 - Broken slips - Equipment fail	1	1
Yes	2	2
04 Prognosticate incident LV 3	0	0
No	1	1

14b - Wrong operation of compen	1	1
Yes	1	1
12b - Lost casing due to slips failu	1	1
Yes	2	2
02 Perceive cues LV 1	0	0
No	0	0
03 Apprehend situation LV 2	0	0
No	0	0
04 Prognosticate incident LV 3	0	0
No	0	0
Yes	0	0
Yes	0	0
04 Prognosticate incident LV 3	0	0
No	0	0
Yes	0	0
Yes	2	2
03 Apprehend situation LV 2	0	0
No	0	0
04 Prognosticate incident LV 3	0	0
No	0	0
Yes	0	0
Yes	2	2
04 Prognosticate incident LV 3	0	0
No	0	0
Yes	2	2
07 - Stuck lose top hole - Wellcont	1	1
08 - Shallow water kick - Wellcont	1	1

APPENDIX 7 - Node and reference overview pr interview

Interview number	*Nodes*	*References*
Interview 01	152	343
Interview 02	138	331
Interview 03	89	182
Interview 05	88	163
Interview 06	72	113
Interview 07	117	218
Interview 08	68	94
Interview 09	66	88
Interview 10	70	105
Interview 11	84	144
Interview 12	85	144
Interview 13	86	151
Interview 14	110	232
Interview 15	98	179
TOTAL	**1323**	**2487**

Note: Interview 4 is missing due to corrupted audio file.

Interview 2,7,12,14,15 contain 2 incidents the rest contains one incident.