

Risk in crane and lifting operations related to the logistic interaction process for well and drilling.

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Preface

This master thesis was written during the spring of 2011, and is part of last year education within the programme of Marine Systems Engineering at the Department of Marine Technology, NTNU. The thesis will be based on a preliminary study written in the fall of 2010; Risk associated with crane and lifting operations.

The assignment was given by Statoil and Marintek. Through the process I have gotten lots of help and inspiration. I especially have to thank my supervisor Professor Bjørn Egil Asbjørnslett, my adviser at Marintek ms. Aud Marit Whal providing me with office space, conferences, flight tickets and good advices, mr. Per Ove Økland, Logistic Field Leader for the Land organisation Gullfaks at Statoil, managing the project, my supervisor at Statoil mr. Atle Aasebø, Procurement Drill and Well Supply Responsible at Statoil, who has answered all my questions and read my work, and ms. Lone Sletbakk Ramstad taking Aud Marit Wahls place at the end of the project. They have all been of great help through the whole process.

The working process has been both been demanding and exiting. Through the process I have observed meetings, been at the supply vessel Havila Foresight and at the supply base Ågotnes, interviewed people and studied statistics. I particularly want to thank captain Odd-Stian Stendahl and his crew at the vessel for taking so good care of us and my interviewee at the Ågotnes.

A great thank to Professor Svein Kristiansen and Phd. student Pedro Agustín Pérez Ramíre for valuable help and advice through the analysis process. I also want to thank mr. Gisle Nygård, mr. Endre Vik, ms. Line Kaldestad, mr. Lars Brekke and Dr. Bernt Tysseland for great reception and insertion in the regime of Statoil.

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Abstract

This master thesis compares the logistic chain of operations and maintenance versus drilling and well and finds how drilling and well affect this chain with regards to risk on crane and lifting operations. Research has been done through accident/incident analysis, statistic, observations and interviews. An influence diagram for frequency is made, to better understanding the risk influencing factors (RIF) that affects a crane and lifting operation. The influence diagram is based on operational-, organisational-, and authority- and customer related risk influencing factors. These factors describe general causes and actors influencing the risk for frequency or consequence of a crane- and lifting operation accident.

The risk influencing factors is modelled in a Bayesian Network (BN) to see how they affect the severity of incidents. To make the BN the program GenIE is used, this is a very useful program to model risk, but can be a bit complicated with regards to many influencing factors and many levels of the factor.

From investigation of the logistic chain, incidents/accidents and statistics there was found:

Underlying causes:

- Simulation and practice 38.5%
- Operators maintenance organisation 14%
- Coordination and planning 24.6%
- Operations, procedures and support 23%

Direct causes:

- Human factors 35%
- Operational working conditions 29%
- Compliance 27%
- Physical/environmentally conditions 9%

Incident:

- Green 96,93%
- Yellow 1,43%
- Red 1,64

When situations are at high risk (red), precautions must be taken straight away. The analysis shows that it will be most efficient to improve coordination and planning; the underlying case is reflected in all the direct causes and will affect all of them in a positive way.

Some measurements will affect coordination and planning easily.

- A lot of misunderstandings could have been avoided if everyone had been using the same technical system, SAP, for ordering and planning. To achieve this goal everyone must learn how to use the system, and use the same part of it. A group of planners from each unit

should meet once a day and work together to make one plan and inform each other about changes.

- For the supply vessel and installation it would have been much easier if every documentation and certification were online, this could make their planning process much easier. Then plans of where the goods should be placed could be done before the vessel enters at the supply base and the installation would have had time to prepare better for reception of the supply vessel. This should be quite easy to implement since all goods should already have a serial number in SAP:
- The milling machine at the installations would also make things much easier, because then not so many containers would need to be shipped to the installations and space and money would be saved.

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Abbreviations

D&W: Drilling and Well

O&M: Operations and Maintenance

IO: Integrated operations

IPL: Integrated planning

Purchasing Order: is the foundation for every acquisition, without this there is in principle no juridical agreement. When a PO is created the number can be found in SAP and based on this number the requestor can ascertain that the order is implemented. If there exist fixed agreements will PO's go to supplier without involvement from purchasing agent. The main rule is that a PO number shall be established before the shipment is sent from the supplier, but in some urgent cases the supplier have to send the shipment out before the PO number is registered. (X2X Maritime og Statoil ASA, 2010)

DPO: Drilling Purchase Order (Yearly PO)

SO: Service Order (Special PO)

SWIRE: Swire Oilfield Services is the world's largest supplier of specialist offshore cargo carrying units to the global energy industry and is a leading specialist in helicopter fuel systems and chemical handling services. (Swire Oilfield Services)

Operators: In this thesis operator is used for the crane operator and his co-workers both at the installation and the supply vessel.

RFID: Radio Frequency Identification (Interview, 2011)

APOS: Arbeidsprosess orientert styring; Work possess oriented procedures

HSE: Health, safety and environment

FAR: Fatal accident rate

BN: Bayesian Network

BNA: Bayesian Network Analysis

1 Introduction

1.1 Background

Crane and lifting operations is an important function in the logistic offshore production chain. Operations where crane and lift is a constitute part is dependent of the quality in the logistic process, which also is dependent of interaction and cooperative planning of the logistic operations. The challenge is the logistic interaction between drilling and well and operations and maintenance; they use different systems for logistic management, follow-up and reporting.

The current problem will be connected to integrated operations (IO). IO is to optimize the coordination of activities and recourses, this to ensure that health, safety and environment (HSE) and production is kept at best possible level. Integrated planning aims to join different disciplinary or domain specific activity plans into one general plan in order to optimize the use of common resources like logistic support and maintenance expertise. (Ramstad, Halvorsen, & Wahl, 2010) To be IO-Safe is to improve methods, processes and tools for ensuring a proactive focus on safety and security in IO. (IO-Center, 2010)

1.2 Improved interaction and safety

How interaction between drilling and well (D&W) and operations and maintenance (O&M) contribute to the safety concerning crane and lifting operations; how enhanced interaction between these in the logistic process can contribute to an improved safety in crane and lifting operations.

1.3 Scope and main activities

- i. Describe the logistic process where D&W and O&M are a constitute part.
- ii. Describe the systems that are used for logistic operations, follow-up and reporting.
- iii. Identify bottlenecks in this logistic process.
- iv. Identify and document measures that can give better interaction concepts.
- v. Document in a quantitative risk model the effect of the suggested measures on the safety in crane and lifting operations.
- vi. Based on the previous analysis; give a recommendation of improvements that can have an effect both in the logistics management and in safety for crane and lifting operations.

1.4 The reports structure

The objective of the analysis is to present an informative risk picture. The Aviation System Risk Model (Luxhøj & Coit) provides a systematic, structured approach to understand aircraft accident causality through Bayesian Network Analysis (BNA), and to provide a means for performing risk assessment of new aviation products. The same can be done for crane and lifting accidents. Risk analysis is a tool to express and deal with uncertainty. Aven discusses (Aven, Pålitlighetsstyring-og risikoanalyse, 2006) how to get a description and communication of risk and reliability in order to achieve effective communication. To form a risk profile for lifting operations based on a qualitative risk analysis, NORSOK Z-013 Chapter 5 and Management Regulations § 15 (Ptil, Styringsforskriften, 2009) and the Aviation System Risk Model has been used as a starting point. Table 1 provides an overview of the process for performing a risk assessment.

Chapter 1: Introduction

Introduces the background and purpose of the assignment work

Chapter 2: The oil and gas industry

The foundation of the assignment is presented. The focus here is to present the historical view of the oil and gas industry from the world to the Norwegian view. The oil and gas industry has changed its ways of thinking, the modern oil and gas industry will be presented; this to give an introduction to the new ways through integrated operations and planning tools. The core of the project is based on information from Statoil; Statoil is the leading oil and gas company in Norway. To understand the factors that influence a crane operation Statoil's logistic chain and planning tools will be presented.

Chapter 3: Research Method

Explains how information from the personnel involved, experts on the equipment, previous risk assessments and regulations are used to establish a framework / context for risk analysis. The risk acceptance criteria are set for what constitutes acceptable risk associated with the activity one is considering, in this case lifting operations. The model for the risk analysis is presented.

Chapter 4: Hazard identification

To provide an overall picture of the risk on the platform it is necessary to identify the hazards that exist and which must be considered. In this phase information is used as mentioned in paragraph one, which consists of past experience, analysis of incidents/accidents and statistics.

Chapter 5: Influence diagram

Based on the identified risks related to lifting operations the experience data and reliability analysis reveal the initiating events that may occur on board a crane vessel or on an installation. These are not expected events, but potential. It is not expected that they will occur, but one assumes that they can occur, and therefore must be considered on how they should be avoided/handled. Risk influencing factor models for frequency is a good tool to determine which events are needed in order to get an initiating event. That is a form of causal analysis of what leads to an undesired initiating event.

Chapter 6: Risk Picture

Having mapped all potential hazardous events and consequences that can occur in connection with lifting operations one can establish an overall picture that expresses the lift risk on the platform. A Bayesian network analysis will give a good picture of today's risk picture.

Then an analysis of the potential risk improvement will be performed. This will show which underlying causes that will have most effect on the risk picture.

Chapter 7: Measurements

From the chapter 6, the most effective change in underlying causes is represented. From this the most effective measurements can be presented.

Chapter 8: Discussion

How the method and assumption affect the results are discussed.

Chapter 9: Conclusion

The result are presented and suggestion for further work.

2 The Oil and Gas Industry

In 1969 a new era started in Norway with the discovery of Ekofisk. Today there are 65 production fields on the Norwegian continental shelf. The oil and gas industry is the largest industry in Norway; it is about three times larger than the industry at land and eleven times larger than the fishing industry. The Norwegian Ministry of Petroleum and Energy expects that even after 40 years of production, nearly 60% of the expected resources remain to be produced. (Ministry of petroleum and energy)

But even though there are still a lot to gain, the accessibility of these findings is more complicated. In the future the sector will be developing smaller marginal fields, going towards deeper waters, using more subsea solutions and floaters. Cooperation with UK, Denmark and Russia will increase. An example on this is The Barents Sea border. Since the beginning of 1970 this has been a discussion between Norway and Russia. The 27th of June 2010, Norway's Prime Minister, Jens Stoltenberg, and Russias President, Dimitrij Medvedjev, agreed to divide the 175.000 square meter area into approximately two similar parts. (TV2 news) This area and other north areas of Norway are some of the most promising fields to still provide viable petroleum activity. The arctic environment and a very narrow shelf will meet strict operational concerns since there are a lot of other factors that will influence the oil exploration. (Løset, Shkhinek, Gudmestad, & Høyland, 2006)

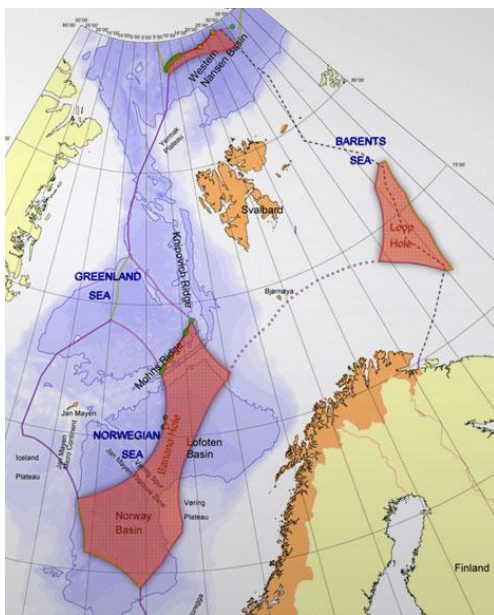


Figure 1 The Norwegian continental shelf

(TV2 news)

As described there are still opportunities related to exploration, field development, improved oil recovery, gas value chain and arctic technology. But there are a lot of challenges and the need for a strong focus on long term planning is required. The two most significant challenges are:

- Resource decline: we produce more oil and gas than we add through exploration and improved oil recovery additions.
- Cost increase: the future unit cost on all the bigger fields will increase significantly, this because of the resource decline.

These two elements give the most considerable pressure to improve the economic efficiency on the Norwegian Continental Shelf. (OLF, 2005)

2.1 Modern Oil and Gas industry

Through the last decades the traditional strategy for managing the complexity of oil and gas fields has been to organize people, work processes and technology in sections. (IO-Center, 2010) The activities on the Norwegian shelf generate a continuous need for supply to and from the installations. To meet this need, a large number of activities have to function; operational-, support- and planning activities. Optimization of offshore oil- and gas production, safeguarding of costs, while considering safety and environmental aspects calls for efficient utilisation of resources. To coordinate all the different amount of activities, actors and at the same time get an overview of all the plans is a huge challenge. (Ramstad & Wahl)

2.1.1 Integrated Operations

To increase oil production, lowering operational costs and prolonging field lifetime while improving the ability to work efficient across geographical, professional and organisational boundaries, the petroleum industry are in the progression of changing their work processes. This is the concept of integrated operations (IO) and is defined by the IO-centre;

“A new way of optimizing the operation of oil and gas fields by making smarter decisions through

- *Integration of people with different experience*
- *Integration of work processes*
- *Integration of information and communication systems from different domains”*

(IO-Center, IO Center Annual report 2009, 2010)

This strategy is not fully implemented yet, and there are many challenges left. In the logistic chain the work processes was described as a serial of work processes with lack of cooperation. Integration of processes can improve production planning and processes, through communication, collaboration, integration of systems, people and information enables better decisions. (OLF, 2007)

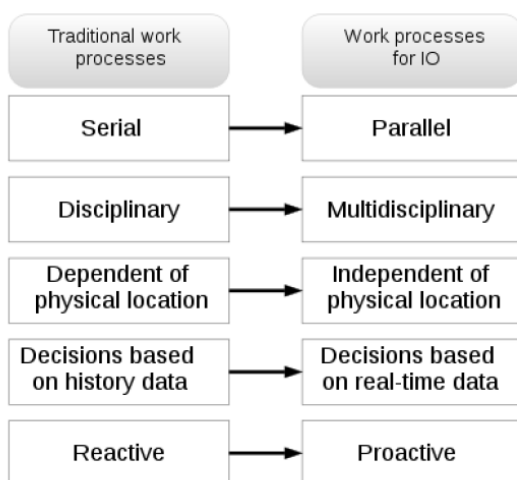


Figure 2 Traditional versus IO work processes

(OLF, 2007) (Apneseth, 2010)

2.1.2 Integrated Planning

Transferring IO principles to the planning domain has led to integrated planning; a strategic tool for optimising operations. (Ramstad, Halvorsen, & Wahl, 2010) The purpose of integrated planning is to coordinate the massive amount of information found in a variety of plans made by several disciplines into one holistic view of work that must be performed in an asset in any given time period. (Ramstad & Wahl, Offshore integrated planning and performance management)

Large amount of information have to be processed and communicated within and between the units in the organisation. By integration of planning processes across organisational domains, identification of critical interrelationships of the overall performance systems can be achieved; this will give a higher quality and better utilization of resources and activities. All the planning processes where operational activities are interrelated and have an influence on the overall performance of an organisation should be integrated in one overall planning process. The planning process should be supported by a software tool that is able to integrate and combine data from multiple sources and give visualisation of a dynamic plan. (Ramstad, Halvorsen, & Wahl, 2010)

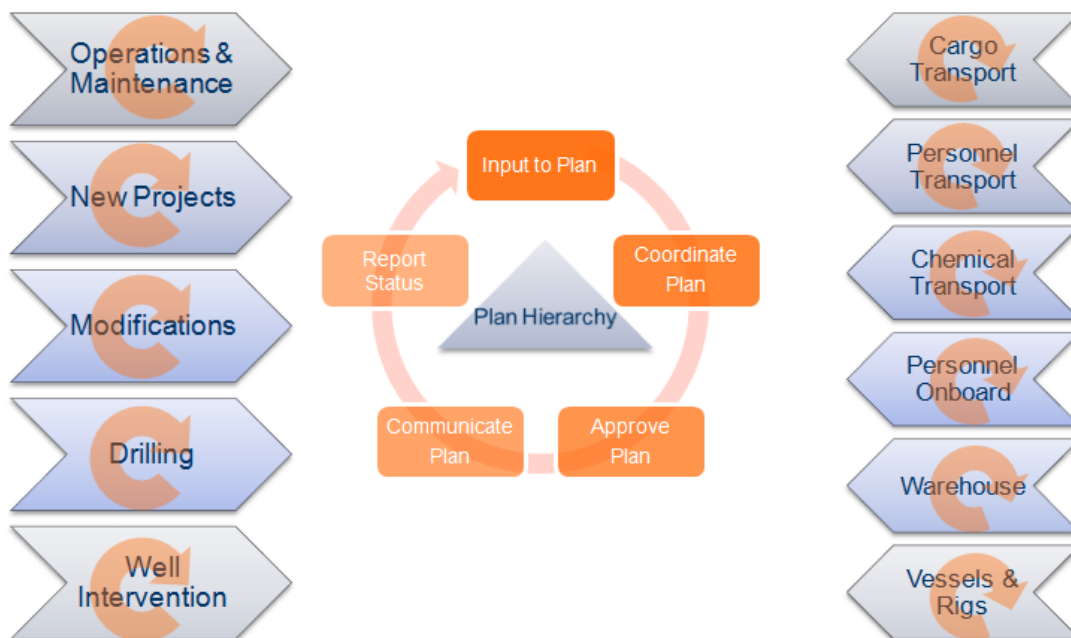


Figure 3 Plan Hierarchy

(Wahl & Holte, 2011)

2.1.2.1 Integrated Practice

The integrated planning process contains activities like scheduling, resource levelling, resource conflict resolution, plan acceptance and plan dissemination. To achieve a successful planning process certain organisational capabilities must be in place. One organisational challenge in establishing an integrated planning process is planning culture. The multi discipline setting where disciplines are operated almost separated as a business entity; where there exist no hierarchical organisational unit on a higher level that will host the integrated planning function. The integrated planning function will support and take operational decision on behalf of other units. This concept will need maturing and management support to evolve to an operative tool. The planning process of each unit should be maintained and coached by a superior team dedicated to add together all the different unit plans. The planning culture is in continuous change and is affected by several factors; data, ICT-tools and infrastructure have to work, there need to be room for collaborative workspace and the structure of the organisation is important. This should be standardised to be able to handle the information equally. The operational plan of the disciplines has to be updated to reflect the agreement made in the integrated planning process, this to achieve a good logistic process. (Sleire & Wahl, 2008)



Figure 4 Planning Culture

(Wahl & Holte, 2011)

2.2 The logistic chain

Statoil has worked hard to find the bottlenecks in their logistic chain; one thing they found was that in the supply chain of jobs, people are rarely satisfied with the previous man's job. The question is "What can be done so that the next unit in the chain can do a good job?". This is the purpose of APOS; it describes all the activities which have to be done in a following order i.e. the logistic chain and the crane operations. The crane operations follows NORSOK-R003 standard. Statoil has focused on compliance of these procedures to reduce the risk for incidents/accidents, but still there is a lot to gain. (Økland, Nygård, Vik, Kaldestad, Brekke, & Tysseand, 2010)

Today the planning of activities is divided; resulting in a challenging coordination. The logistic chain is described with regards to O&M activities and D&W activities. The statistic shows that in 2010 14.3 percentages of the serious injuries of crane and lifting accidents was due to crane and lifting operations.

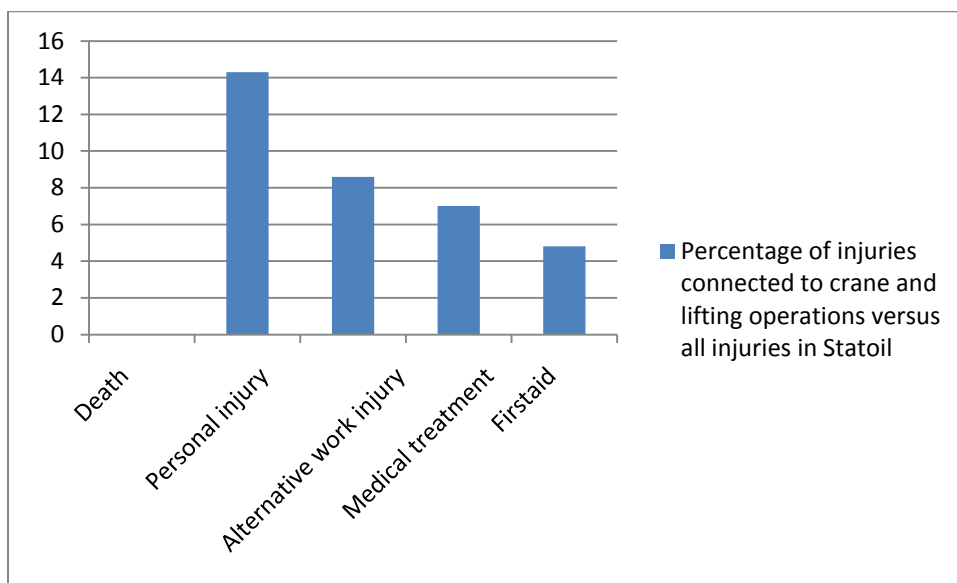


Figure 5 Injuries in Statoil as a whole versus injuries in only lifting operations

(Statoil, 01.01.2010-01.01.2011)

The crane operations are the end station for this logistic chain. To understand what makes the crane operations so vulnerable, the logistic chain have to be understood.

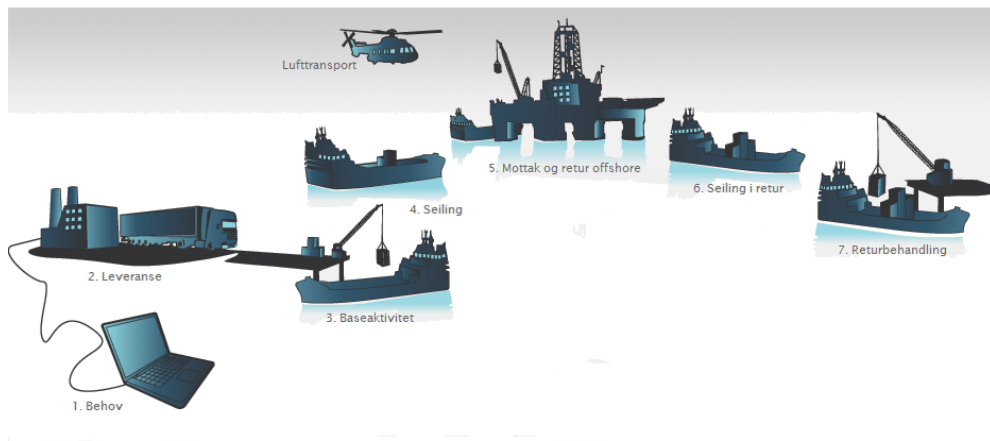


Figure 6 The logistic chain

(Logistikkportalen, Statoil, 2010)

1. **Requirement:** The offshore facility has a continuous need for material and goods. There are several segments that are involved in the logistics requirement from the installation. It can therefore be challenging to coordinate and plan all the activity levels. One must be aware of that not every requirement trigger a procurement i.e. some materials are stored at one or more of Statoil's bases. There are certain guidelines (APOS) for registration requirements. If they are not followed it will have consequences for the next segment in the logistic chain, and it makes prospective planning difficult. It is also important that time schedules are followed for outgoing and returning goods; the consequences can be extra work and delays for the whole chain. The requirement is administrated in the land organisation or at the installation, most requirements come from one of five departments; drilling, well intervention, maintenance and catering or oil, gas and produced water separation. (X2X Maritime og Statoil ASA, 2010)

For the logistic chain to be working optimally planning is necessary. O&M administrate their need in a Planning Hierarchy in SAP. There are five different main planes which make the framework of the planning process:

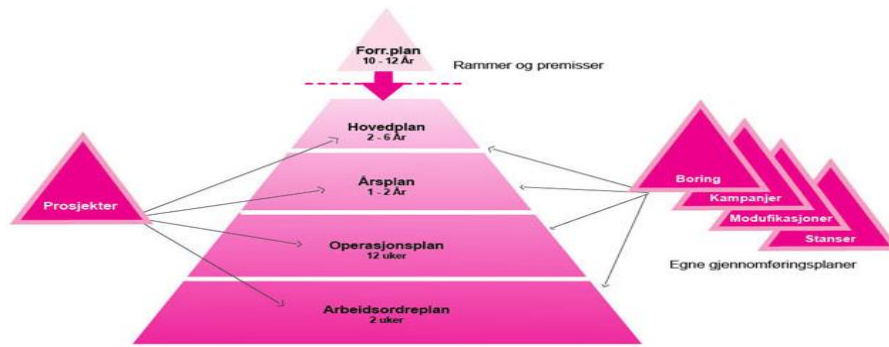


Figure 7 Framework for the planning process

(Økland, Information received during Statoil meetings, 2010/2011)

- Business plan (Forr.plan): a long term plan for 10 to 12 years ahead. Here bounds and terms for strategic planning is set.
- Main plan (Hovedplan): Here more detailed information regarding operations and demand are set for 2 to 6 years.
- Annual Plan (Årsplan): Gives the frame for 1 to 2 years ahead.
- Operational plan (Operasjonsplan): 12 weeks ahead.
- Work order plan (Arbeidsordreplan): Is a continuous 2 weeks plan that is updated from day to day. The work order plan is based on every major O&M activity offshore and some smaller daily operational activities. It shows what to do and estimates need of recourses and equipment/materials. Even though need of equipment/material are in the work order plan it will not be shown because it is too detailed for the plan; thus the work order plan will not satisfy the operational needs and show what goods going out when. Once a day a work order-meeting is carried out, notifications that are manufactured the last 24 hours are considered; work order's are established in the cases where it is considered needed. Most of the equipment for O&M are not tied to unexpected actions i.e. D&W, though need of some equipment can occur sudden. Therefore work order's are prioritized according to rush order; work order's with high priority are carried out immediately.

(Økland, Information received during Statoil meetings, 2010/2011)

D&W have a different ordering process than O&M. A downhole target is requested. The requisition goes to a well engineer; he plans the job and the equipment needed. Suppliers, service companies and others that are involved in the job is invited to contribute with their competence; they request what equipment they think are needed in eBOB. The well engineer has to approve the needs from the involved parties. He makes a Need list¹; which is a detailed list over the equipment needed and shipment date at the base; the equipment can be an article in stock or for purchasing. The point is to "order what you need, and to optimize

¹ The Need list is just an extract from the eBOB, not a part of it. It is possible to generate reports from eBOB but these do not have the wanted layout.

the time of dispatch". To order, a Procurement Drill and Well Supply Responsible is the contact point towards the suppliers. Based on the requisitions in SAP, eBOB, the Procurement Drill and Well Supply Responsible creates a purchase order number for the order; this purchase order number can also be created automatically without the Procurement Drill and Well Supply Responsible. An approximately time of dispatch is already given to the suppliers during the planning process. For optimizing the time a Drill and Well Supply Responsible estimate the exact deliver date based on the progress in the drill and well process. D&W uses for this purpose a planning tool called Project Planer; on daily basis a Daily Drilling Report is composed to show the progress. Nothing goes out before Drill and Well Supply Responsible has given the enabling signal.

In addition to the different planning operations, different requirements are registered in different ways (X2X Maritime og Statoil ASA, 2010):

- Equipment is registered in the work order plan: a requisition is generated to Statoil's purchasing agent, which is responsible to execute a pro-active coordination, planning and accomplishment of the acquisition. It is the purchasing unit that negotiate and enter into contract with the suppliers. When a need is registered, the procurement agent chooses a supplier and sends out a purchase order. If there is a binding contract with a supplier the purchase order will go direct from the work order plan to the supplier without intervention from purchasing agent.
- Bulk (cement, water, chemicals and barite) is registered in a drilling operations contract related purchase order (DPO): every DPO registered come from a purchase order and in many cases a DPO is characterised as a yearly purchase order. Bulk is ordered in many ways; through MDM SRM E Catalog Purchaser/Contract Handler or an old version of this, through phone or mail. This makes it difficult to keep track of the orders. (Ågotnes, 2011)
- Service: Leasing of equipment or personnel requires a special purchase order called service order. There exists no procedure on pre-enrolment for need of transport. The equipment is delivered at the base, and one hopes that it will sail with the next supply vessel. A problem with leased equipment and personnel is that the personnel that should use the leased equipment want to be sure that the equipment is at the installation before they arrive. This lead to more equipment for storage at the small spaces at the installations.
- Material in stock: The base receives an order pick list, and uses this to collect the wanted items. A purchasing agent is most often not involved in this process. When material is taken out of stock an automatic order for new material is most often created.

Confirmation of order: Today the purchaser decides if he wants confirmation of order or not, often he gets the confirmation on either mail or fax. Based on SAP it is possible to see when the order was registered. The confirmation of order is similar for O&M and D&W, but the Drill and Well Supply Responsible often gets an oral confirmation when the Drill and Well Supply Responsible gives the enabling signal. (X2X Maritime og Statoil ASA, 2010)

2. **Delivery:** When it is time for delivery, the supplier/subcontractor receives an order from the purchasing agent at Statoil. The supplier/subcontractor prepares and secures the goods for transport. The goods should have a packing notification which should contain contract- and order number, description of the shipment, name on the consignor and recipient. Certifications, EHS- data sheets and hazardous goods consignment note. It should tell where the goods should be delivered so that sorting at the base could be easily done. If the material is of a hazardous substance, the marking should give information about which precautions that are necessary. The material could also need special treatment to avoid transport damage. Majority of all equipment is packed by supplier/subcontractor, but some are sent to the base for packing. Then the goods are transported to the supply base, mainly by Grieg logistic and Bring.

3. **Base:** At the base goods is packed, handled and loaded on the supply vessels. Statoil Marine controls the sailing schedule for vessels and installations (Marine operations); this makes the plan basis for how the supply vessel should be loaded.

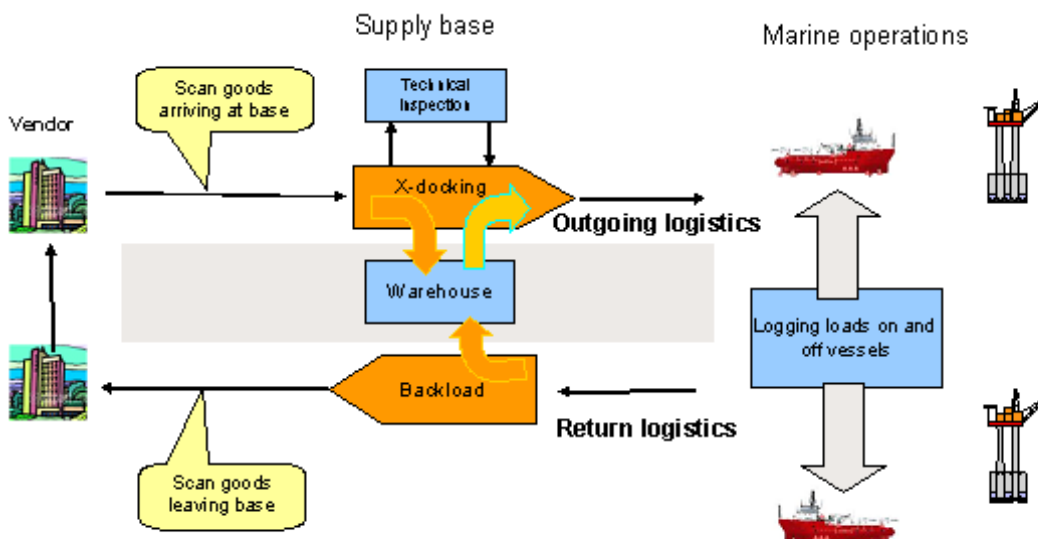


Figure 8 The interaction process at the supply base

(Statoil; Ågotnes, 2010/2011)

When the goods arrive at the base documents are handed over to the base. If all is in order the cars will be discharged and the goods are checked, if not the base will make a deviation in order. A quality control is completed for the individual group of material, a SAP serial number is then fasten to the packages. Then the packages go to stock or technical inspection for check-out before or directly to co-packing. The goods are then prepared and secured for further transport to the installation, this in accordance with safety regulations. The rule is that shipments shall arrive at the base before 16.00 the day before dispatch. Exceptions are provisions and hired equipment which must arrive before 10.00 the day of dispatch. Need for bulk transport must be registered 48 hours before the supply vessels planned time of departure. To organise the goods that are to be sent each day to the

installations, there is a morning meeting at the base; here the material coordinators of D&W enrol the material that are going to the installations the same day. The terminal sets sailing schedules continuously in SAP; for both O&M and D&W, a shipment number is generated. Automatically a list of goods are generated which are attached to shipments and load carriers continuously while they prepare and pack. When the list of goods is finished the terminal work further with the loading plan, prepare papers that have to follow, and load the vessel.

Statoil Marine is responsible for creating routing in SAP VTMS within 10:00; taking into considerations the requirements from installation, vessel and other logistic actors until 12:00 when the plan is considered final. At approximately 13:00 a load meeting at the base with operation planners, loading/unloading leader and the captain/1.offiser; here it is decided where the goods should be placed at the vessels deck to best satisfy every requirement. Then the goods are loaded onto the supply vessel according to the plan. The supply base is responsible for delivering an overview of the loaded goods in SAP.

4. **Sailing:** As mentioned above Statoil Marine is responsible for the vessel routing plan and the vessel during sailing.
5. **Reception and return offshore:** The most hazardous part of the logistic chain is when goods are to be received through a crane and lifting operation. The installation need to be ready for operation so that it does not collide with other work operations. Preparation of all returning goods (safely packed in containers/baskets); the goods shall be registered in SAP before 10:00 the day the supply boat leaves from base. A return notification shall be generated in SAP; number, volume, weight, etc., shall be registered so that the base can plan the need for vessels and deck space. Especially dangerous goods shall be marked. According to SAP there exist 13 different return types. The captain of the vessel should get information about the goods he is returning as early as possible to be able to handle dangerous goods. Good communication between the involved parties is a must, transport documents need to be shared in an early stage. Transport documentation on inbound goods is delivered from the installation to the supply vessel before the vessel is leaving.
6. **Sailing:** After departing the safety zone of the last installation on the rout, the vessel report the following to the base; backload, undelivered goods, bulk delivered and received, vacant deck area, arrival and departure time and delays. The base prepares for the vessel arrival by assigning quay, mobilising necessary cranes and bulk handling equipment as well as creating a plan for unloading the vessel.
7. **Management of the returned goods:** 75% of the material shipped offshore, returns to land. The unloading of the returned goods is planned in a meeting by the base. Returned goods are sent away for repairs, stored at the base, returned to supplier or disposed. Hazardous goods are to be stored for as short time as possible.

(Logistikkportalen, Statoil, 2010) (Vik, 2010) (X2X Maritime og Statoil ASA, 2010)

2.2.1 Systems

In the logistic chain different systems were described. A comprehension to how these systems interact or not and how they affect the planning process is needed. The main system used is SAP, and it will therefore be the main focus. Other systems are either a part of SAP or used instead of SAP, but the target to attain is that all systems are a part of SAP.

- **SAP:** Statoil's Enterprise Resources Planning System is called SAP. This is module based software used for: accounting, sales and distribution, procurement and stock control, logistic, maintenance, production and personal treatment. (SAP, 2010)
The program itself is very good but it has a very high entry level, which makes it very difficult to use. It receives each requirement, but one cannot see the whole picture which makes it difficult to plan with regards to several factors. SAP is a very large program, there are different modules that can do basically the same; this can make it difficult to gather all information into one total plan.
Another problem is that 40% of all cargo going out to the installations is not planned in SAP, and SAP is not used by all the departments at the installation. Drilling uses their reporting line which leads to difficulties during planning. There is lack of control in what equipment that is needed and what equipment that is stored at the installation, this leads to extra supply calls and urgent cases with high priority level. (olf, 2005)
- **DaWinci (D&W and O&M):** A tool for planning and booking of helicopter transport to and from the installations.
- **VTMIS (D&W and O&M):** Vessel Traffic Management Information system is a module used at the base and by Statoil Marine, it works as a support tool for rout planning of the supply ships. Shows what vessel, status; operative or planned which region they are in, what type, which site and if they are mobilized. It is also detailed with a colour map which describes where the vessel are going (future), delayed departure, delayed arrival, at site, past/cancelled.
- **LogiC (D&W and O&M):** Is a tool that visualises graphically information from VTMIS, DaWinchi, weather reports and information about the installations. It is bound to visualise sea- and air transport.
- **eBOB (D&W):** A module used for planning of needs/requests by D&W.
 - **Needlist (D&W):** A Lotus Notes tool that is used to get a more detailed overview of what needs and when the equipment will be needed. A large part of Needlist is extracted from eBOB, but contains more information than found in e BOB.
- **Project Planner (D&W):** A planning tool for detailed progress planning of D&W operations.
- **MDM SRM E-Catalog Purchaser/Contract Handler (D&W):** Is a Lotus Notes tool that is used for call-off, coordination and tracking of D&W shipments till the installation, it works really good but has a missing functionality on return from the base. It is mainly built on information from Needlist and Project Planner. A new MDM SRM E-Catalog Purchaser/Contract Handler is under development in SAP.
- **Vendor portal and Hubwoo (D&W and O&M):** Statoil has today four easy to dispatch automatically orders; fax, e-mail, vendor portal and hubwoo. The vendor portal is a part of SAP and is a relatively new solution; it is also the preferred solution.

(X2X Maritime og Statoil ASA, 2010) (IO-Center, 2010)

3 Research method

To find the challenges in the logistic chain; fieldwork, document study and interviews in parts of the logistic chain² has been performed. The study focuses on bottlenecks within the chain and what wanted measurements there are. To establish a realistic model there is a need to systemize results from statistic, research data and experts. A process to achieve this is needed. (Vatn, 2006)

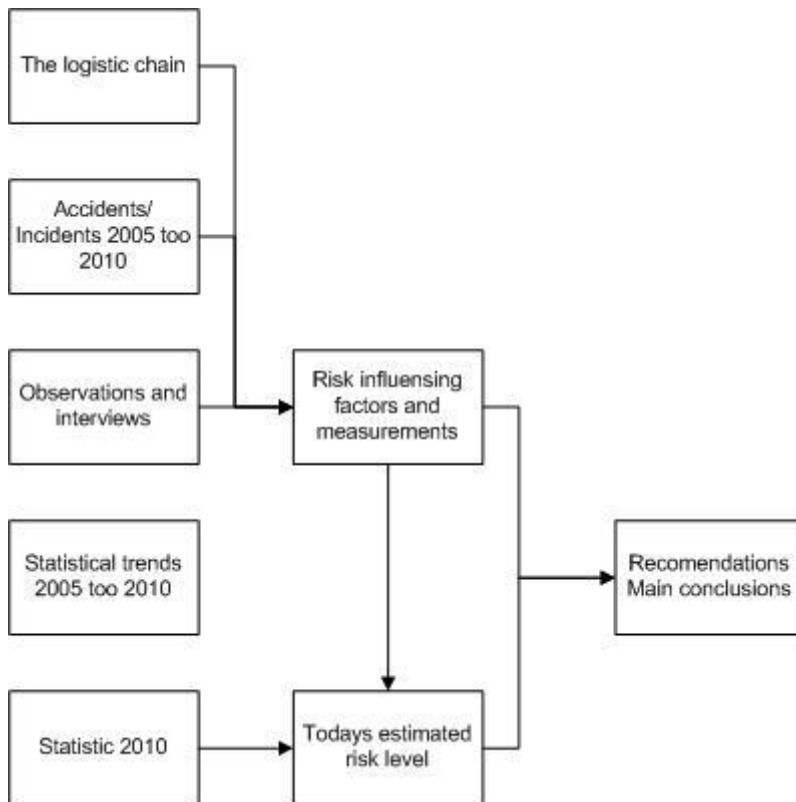


Figure 9 Methodical approach

3.1 Data sources, use of statistic and interviews

The accident investigation is done with regards to reports from Petroleum Safety Authority Norway. Statistics about incidents/accidents in Statoil is taken from Synergi, Statoil's internal reporting system, and reports written by Statoil about the subject.

The reports are mainly used to find direct and underlying causes to incidents/accidents and to map how incidents/accidents happen. Here all crane- and lifting operations that have lead to incidents/accidents from 2005 till the end of 2010 are looked into.

Statoil has already investigated their logistic chain through the X2X report (X2X Maritime og Statoil ASA, 2010). This has been used as a basis to understand the logistic chain and suggestions to measurements.

² Suppliers, transporters and installation have not been visited in this part of the assignment. But people who work/have worked at the installation have been talked to.

The findings from the statistics make the foundation for:

- Quantification of today's risk level
- Identification of typical incidents
- Definition of risk assessment criteria

The thesis is mainly based on interviews, attendance to meetings and observations; this to understand the diverse problems the different units of the logistic chain experiences, what they think is wrong and what measurements that can be done. This gives insight in the work days and a mostly correct view of the reality.

Information has been gathered through:

- Observations during:
 - Morning meetings with different parts of the chain.
 - Planning meetings
 - Phone meetings
 - Visited Base and Supply vessel.
- Interviews and conversations with individual persons

3.2 The risk assessment criteria

The risk acceptance criteria should always be decided on before the start of any operation. There will be different criteria for operations and for survival. Risk is quantified as the product of the frequency f of incidents and their average consequence k .

$$R = f \cdot k$$

f =incident frequency

k =incident consequence

This often is represented as the fatal accident rate (FAR) value; to satisfy the normal offshore risk criteria, the annual probability must be less than 10^{-4} or have a return period less than 10 000 years. Safety is commonly defined and measured by the relative occurrence of the unwanted outcomes. The set of possible outcomes can be described in the figure 10 below.

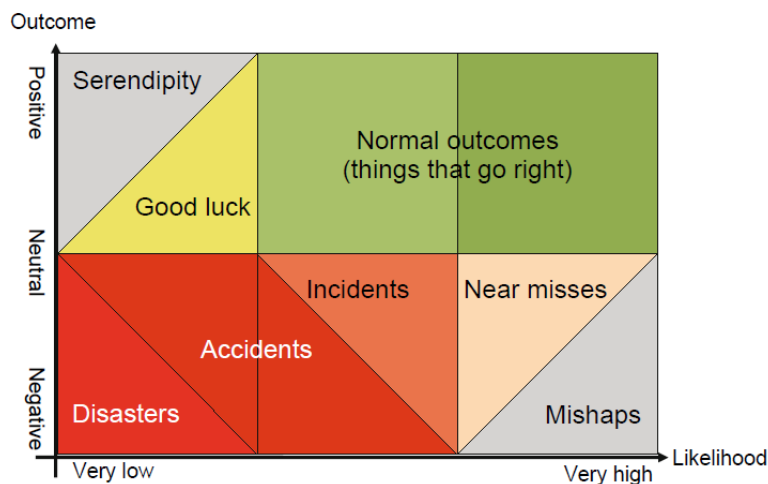


Figure 10 Possible outcomes

(Hollnagel, Tveiten, & Albrechtsen, Resilience Engineering and Integrated Operations in the Petroleum Industry, 2010)

Figure 11 shows a risk matrix which is a useful tool for describing risk (DNV, 2009). The vertical axis shows probability of failure and the horizontal shows consequence of failure. The normal offshore risk acceptance criteria will place the probability in the medium risk level or below. The risk matrix for Statoil crane and lifting operations can be seen in appendix H.

Being in the green zone means low risk. Generally no action is necessary as the risk is acceptable.

Yellow means medium risk. This is the “as low as reasonably possible” (ALARP) region. A risk reducing measure should be taken as long as it is not proven that the cost is in “unreasonable disparity” to the benefit gained (Aven, 2007, p. 32).

While in the red zone the risk is high. This is the unacceptable area. Risk reducing measures must be taken to reduce probability, consequence or both, so that the risk is within the acceptable region.

PoF Ranking	PoF Description	A	B	C	D	E
5	(1) In a small population, one or more failures can be expected annually. (2) Failure has occurred several times a year in the location.	YELLOW	RED	RED	RED	RED
4	(1) In a large population, one or more failures can be expected annually. (2) Failure has occurred several times a year in operating company.	YELLOW	YELLOW	RED	RED	RED
3	(1) Several failures may occur during the life of the installation for a system comprising a small number of components. (2) Failure has occurred in the operating company.	GREEN	YELLOW	YELLOW	RED	RED
2	(1) Several failures may occur during the life of the installation for a system comprising a large number of components. (2) Failure has occurred in industry.	GREEN	GREEN	YELLOW	YELLOW	RED
1	(1) Several failures may occur during the life of the installation for a system comprising a large number of components. (2) Failure has occurred in industry.	GREEN	GREEN	GREEN	YELLOW	YELLOW
CoF Types	Safety	No Injury	Minor Injury Absence < 2 days	Major Injury Absence > 2 days	Single Fatality	Multiple Fatalities
	Environment	No pollution	Minor local effect. Can be cleaned up easily.	Significant local effect. Will take more than 1 man week to remove.	Pollution has significant effect upon the surrounding ecosystem (e.g. population of birds or fish).	Pollution that can cause massive and irreparable damage to ecosystem.
	Business	No downtime or asset damage	< € 10.000 damage or downtime < one shift	< € 100.000 damage or downtime < 4 shifts	< € 1.000.000 damage or downtime < one month	< € 10.000.000 damage or downtime one year
CoF Ranking		A	B	C	D	E

Figure 11 Risk matrix

(DNV, 2009)

3.3 Model

Accident analysis and risk assessment are methods needed to deal with the problems coming from major accidents. Historically the methods have been developed to deal with major technological developments or to cope with “new” types of accidents. Below the figure 12 describes some well-known methods used to address technical, human factors and organisational factors. The model do not describe the method used in this assignment but it is noteworthy that human factor methods came to the scene after the accident at Three Miles Island in 1979 and organisational after Chernobyl and Challenger in 1986. (Hollnagel, Department of Computer and Information Science)

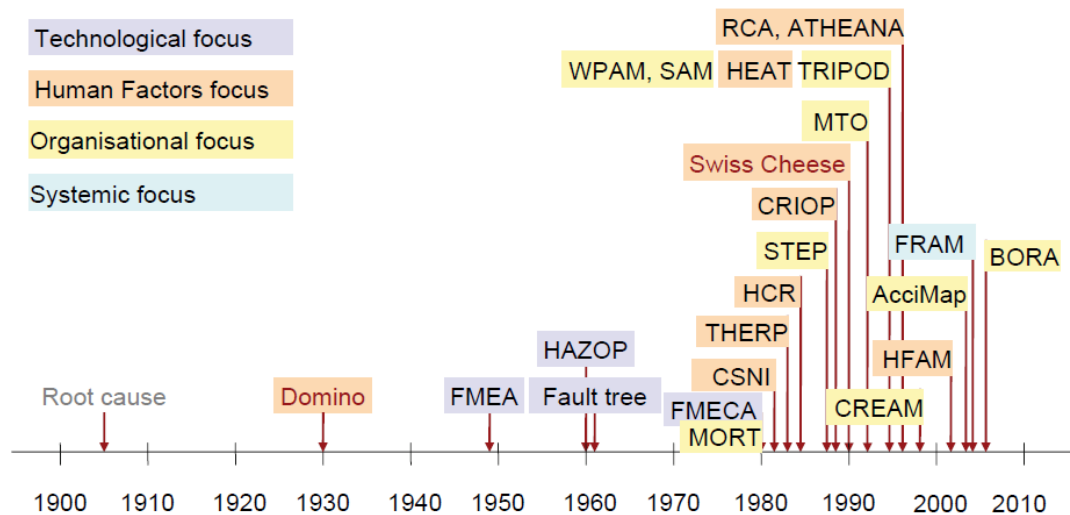


Figure 12 Methods

(Hollnagel, Tveiten, & Albrechtsen, Resilience Engineering and Integrated Operations in the Petroleum Industry, 2010)

Since the complexity of industrial systems continues, it is inevitable that established approaches to risk and safety at some time become unable to explain, predict and prevent new types of accidents. Today the variability of methods must often be combined to address the more complex phenomena.

There are many individual instances of such accident models, but they all seem to fall into three types of accident models: (Hollnagel, Department of Computer and Information Science)

- **Sequential models:** Searches after a specific cause and have well defined links between these causes. The goal of the analysis is to eliminate or contain causes. Examples for these kind of models are:
 - Chain or sequence of events
 - Domino
 - Tree models
 - Fault tree
 - Event tree
 - Network models
- **Epidemiological models:** Searches after “carriers”, barriers and latent conditions. The goal of the analysis is to make defences and barriers stronger. Examples:
 - Latent conditions

- Carrier-Barriers
- Pathological systems
- **Systemic models:** Searches after tight couplings and complex interactions. The goal of the analysis is to monitor and control the performance variability. Examples:
 - Control theoretic models
 - Chaos models
 - Stochastic resonance (Hollnagel, Thinking about accidents)

In the following a sequential model will be pursued.

3.3.1 Bayesian Network Analysis

Through the analysis the Helicopter Safety Study 3 (Herrera I. A., Håbrekke, Kråkenes, & Forseth, 2010) will be used as a template, this template basically assumes that incidents/accidents can be described as a result of cause effect relations. The basic idea is that incidents/accidents can be explained by finding out what went wrong, which can be either a single or a composite event. The approach commonly represents the risk using a graphical form of a tree or a network, called an influence diagram. Further the Helicopter Safety Study 3 uses FRAM to model the risk, while in this assessment the Bayesian Network (BN) has been used to find the relationships. (Herrera I. A., Håbrekke, Kråkenes, Hokstad, & Forseth, 2010) (Vatn, 2006)

3.3.1.1 Influence diagram

Is graphical form of a tree or a network built up of nodes and arrows. The nodes represent decisions, intermediate states and risk modelled based on accident categories and risk influencing factors, RIF. A RIF can be a separate group of conditions which can be associated with, in this case, crane operations; it is a condition or a circumstance that has some influence on the risk. The arrows represent cause and effect, it is important to realise that the arrows indicate the relationship, but does not say how strong this relationship is. (Vatn, 2006) (Herrera I. A., Håbrekke, Kråkenes, Hokstad, & Forseth, 2010)

As mentioned above the influence diagram is copying the way the HSS3 has developed their model. The goals of the model is to demonstrate which RIF's that contribute the most to the overall risk, and thereafter it can be discussed which measures that are most profitable in terms of safety.

Our influence diagram can be divided into accident frequency and accident consequences; where accident frequency describes what can lead to an incident, while accident consequence describes the process of preventing the outcome to worsen.

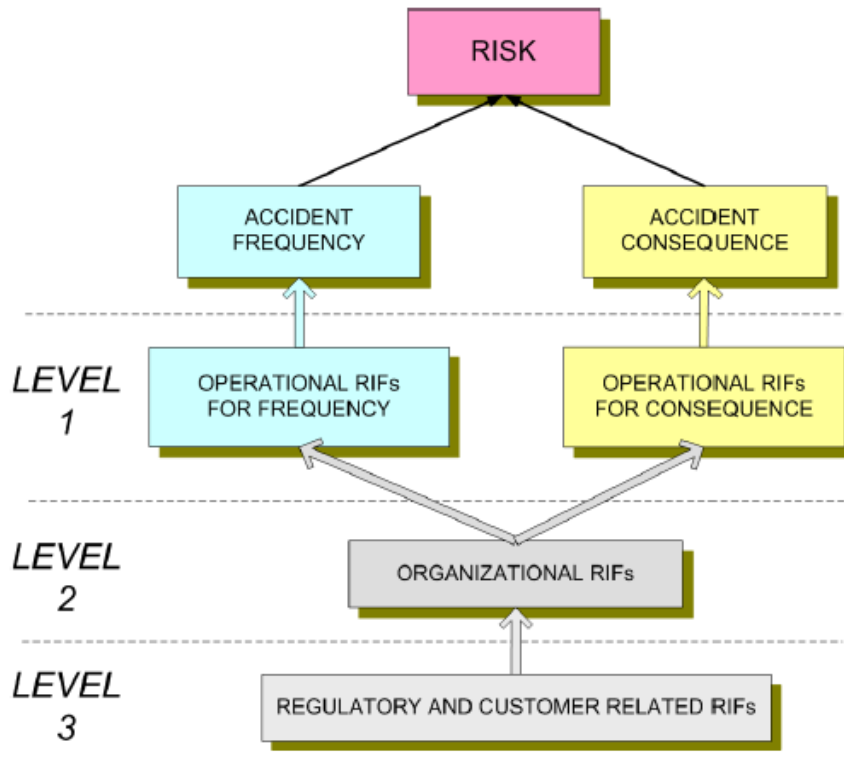


Figure 13 General risk model

(Herrera I. A., Håbrekke, Kråkenes, & Forseth, 2010)

The main causes above level one are not RIF's, they can be described as general causes that represent a grouping of the operational RIF's on level one.

- 1.) Operational RIF's: Risks related to the daily activity to achieve safe and effective crane and lifting operations.
- 2.) Organisational RIF's: Risk related conditions that is related to organisations and their support and control with activities within crane and lifting operations
- 3.) Authority- and customer related RIF's: Risk related to requirements and activities from the authority and customers.

3.3.1.2 Bayesian Network

After the influence diagram is set, a probabilistic model can be performed. A necessary premise for classical probability theory is to either have fully knowledge about the phenomena or a large amount of relevant data to do statistical analysis. Binary-node Bayesian Belief Networks or Bayesian Network represents the counterpart to classical probability theory. Based on degree of confidence or degree of certainty the Bayesians define risk. The Bayesian approach do not require a large amount of data or complete knowledge about a subject, but by combining statistics and expert judgment the risk can be defined. (Kaplan, 1997)

“Probability theory is an extension of logics, which describes the inductive reasoning of an idealized being who represents degrees of plausibility by real numbers. The numerical value of any probability (A/B) will in general depend not only on A and B, but also entire background of other propositions that this being is taking into account. A probability assignment is “ subjective” in the sense that it describes a state of knowledge than any property of the “real world; but this is completely “ objective” in the sense that it is independent of the personality of the user; two beings faced with the same total background of knowledge must assign the same probabilities.” –E.T. Jaynes (Kaplan, 1997)

A Bayesian network is commonly represented as a graph consisting of a set of nodes and arcs; it can be illustrated as an influence diagram connected to probability. A more precise description is an acyclic directed graph in which nodes represent random variables and the arcs represent the direct probabilistic dependents among them. The network can be used to quantify how the RIFs impact accident frequency, accident consequence or risk. The total number of RIFs should measure the change in risk of the main causes of an accident. By focusing on significant dependencies, system complexity is reduced in the model. The main difference in the Bayesian approach and for example a Fault Tree Analysis is that this is a subjective approach which can be based on our beliefs and experience. It allows analysts to use commonsense and real-world knowledge to eliminate. The numbers used in such analysis are often based expert judgments or statistic. (Rausand & Utne, Risikoanalyse - teori og metoder, 2009) .

Mathematical definition:

“Let us consider n random variables A_1, A_2, \dots, A_n , a direct acyclic graph with n numbered nodes, and suppose node j ($1 \leq j \leq n$) of the graph is associated to the A_j variable. Then the graph is a Bayesian network representing the variables A_1, A_2, \dots, A_n , if:

$$P(A_1, A_2, \dots, A_n) = \prod_{j=1}^n P(A_j | \text{parents}(A_j))$$

where; $\text{parents}(A_j)$ denotes the set of all variables A_i such that there is an arc from node i to node j in the graph.” (Pourret, 2008)

Bayesian networks are used for calculating new probabilities when you get new information, as described in the Aviation System Risk Model (Luxhøj & Coit). It can be difficult to connect statistically how the different units of the logistic chain affects the risk of crane and lifting operations, and to see how different measurements affect the risk; estimated beliefs can be used to inserting evidence. During construction of the network one will almost always be uncertain of the correctness of the conditional probabilities specified, either they are specified manually or learned from data. An interval for each probability to range between is usually set, and then a number in this interval is chosen. This interval can then used as a prior for the next case. This is called the second-order uncertainty. (Jensen & Nielsen, 2007)

4 Hazard identification

Experience gained in the petroleum activities up to the present have amply demonstrated the risk inherent in the activities. The last decade the focus on crane and lifting operations has increased, 14% of the fatal accidents with severe personnel injuries are connected to lifting operations. It is often a lot of energy involved in crane and lifting operations. Falling objects can lead to severe personal and material injuries. Number of incidents shows that the use of strap, wire clamps, securing and fitting of pipes require extra attention. Lifting operations are a quite regular process and therefore the lack of awareness may be a contributing factor. To find the RIF's, interviews, observations, accident analysis and statistics is researched.

4.1 Accidents and Incidents

First an overview of all the incidents/accidents connected to crane and lifting operations happened on the Norwegian shelf since 2005 to the end of 2010 has been made. The cases considered can be seen in Appendix B. (Petroleumstilsynet, 2010). The found similar causes between the accidents could be divided into operator's maintenance organisation, simulation and training, operations, procedures and support and coordination and planning.

- Simulation and training
 - Insufficient risk identification
 - Communication
 - Not doing proper job
 - Persons under hanging load
 - Insufficient knowledge of procedures
 - Lack of competence
- Operator's maintenance organisation:
 - Technical weaknesses
 - Lack of maintenance
 - Failures from crane manufacturer
 - Absence of safety function
 - Insufficient design
 - Technical solution
 - Documentation, like instruction manual
 - Weakness in the control system
- Coordination and planning
 - Insufficient directing
 - Insufficient planning
 - Insufficient distribution of responsibility and communication lines
 - Insufficient follow-up
 - Lack of planning, performing and risk assessment
 - Insufficient procurement, control and usage of provisional equipment
- Operations procedures and support
 - Persons under hanging load
 - Supervision and inspection of the system
 - Lack of danger and safety specifications
 - Insufficient compliance of controlling documents for lifting operations
 - Insufficient job description

4.2 Statistic

After studying incidents/accidents inquiries, the material can be further substantiating by statistic (see Appendix D). From the incidents/accidents the similarities were grouped, this grouping can be defined as the organisational risk influencing factors or underlying causes. Underlying features are important but often not so obvious, and as defined in chapter 3.4.1.1 related to organisations and their support and control with activities. The direct causes or operational causes are the risk influencing factors related to the daily activities throughout the logistic chain. As organisational there are many operational factors, but many of them are very similar and affect each other; the direct causes are therefore also grouped. The statistics is from 01.01.2010-01.01.2011 and only incidents with crane and lifting operations connected to D&W.

4.2.1 Underlying causes:

- **Simulation and Practice:** Simulation and practice is a great way to learn about risks and how to tackle certain situations. It is very important that every part of the logistic chain has a comprehension for the next, this seem to be a big problem in the organisation. Simulations and practice will increase the level of awareness and the level of the operator's competence. It can also contribute to make the operators more aware of what is happening during a lifting operation, what dangers there are, and what can be done ahead to decrease this risk. Lack of risk awareness, not enough knowledge about rules and regulations and comprehension of what the next part of the logistic chain needs, seems to be the factor that should have increased relevance during simulation and practice. From the statistical calculations 38.5% of the direct causes of an incident are related to lack of simulation and practice.
- **Operator's maintenance organisation:** Support from the organisation is very important to get the operators to comply with the procedures; it shows that the organisation care about their crew. It seems like the operators maintenance organisation is rather good, but need to focus more on follow-up and maintenance of equipment. From the statistical calculations 14% of the underlying causes of an incident are related to lack of support from the operator's maintenance organisation.
- **Coordination and planning:** Today the coordination and planning is done by many different units and with different technical solutions. The planning process is initially done in both O&M and D&W with a long term perspective, but since D&W's need emerge more suddenly they follow up their plans more closely and make more often changes in transit. The whole chain has a common understanding of superior goals related to production, HSE and costs, but each part only sees their own goals. This leads to sub optimization and worse conditions for the next part in the chain. D&W know that their needs are always prioritized because of their important role in production, which has in some scenarios lead to misuse of the prioritising. The division of the planning activities, planning tools and lack of communication leads to many different plans and difficulties in coordination and cooperation. The plans are not coordinated enough or flexible enough to deal with other than some environmental variations; coordination requires both information processing and communication across different units.

Coordination and planning can be divided into:

- Technical solutions
- Purchase O&M
- Supplier
- Purchase D&W
- Installation
- Onshore base
- Statoil Marine
- Other organisations
- External factors³.

To change this trend the information processing has to increase in the organisation, where the planning tools is the lateral link of the information sharing process. Statistic shows that the largest factor of coordination and planning is lack of work preparation. From the statistical calculations 24.6% of the direct causes of an incident are related to lack of coordination and planning.

- **Operations, procedures and support:** It is worked a lot with procedures and support during operations, APOS cover almost all the work processes, but one of the largest factors leading to accidents is breach of procedures. From the statistical calculations 23% of the direct causes of an incident are related to defective or not followed operations, procedures and support. Procedures are mainly set to secure safe operations.

4.2.2 Direct causes:

- **Human factors:** Knowledge about human factors can give an understanding of what leads to human failures. From a statistical point of view, arbitrarily actions are not the reason for human failure, but a series of out of control conditions. (Petroleumstilsynet, 2010) . Human factors are very much dependent on simulation and practice; with good and often simulation and practice the operators should be able to foresee unwanted incidents. It is also related to the operators' maintenance organisation, which is related to culture. Human factors can be divided into:
 - Culture
 - Competence
 - Awareness of risk

These three factors are dependent on each other and are therefore considered as one. From statistics it is shown that approximately 35% of the incidents are due to human factors. The largest factor is lack of attention and considerations regarding risk, other common factors are equipment/material used incorrectly.

- **Operational working conditions:** Operational working conditions and human factors affect each other, but the operational working condition will be more dependent on technical solutions, equipment and the surrounding working environment. One example of an operational condition that can lead to the human factor awareness of risk is tiredness; the

³ External factors like weather could have been an own underlying cause, but since weather reports are given continually, this is a part of the planning procedure.

operators on both installation and supply vessel are working on shift, and the workers at night are often more unaware than at day. The crew's ability to perform its assigned tasks requires good environmental working conditions. The operational working condition is dependent on maintained equipment, physical working conditions and organisational working conditions. The most common incidents because of operational working conditions are due to equipment failure or bad design. Approximately 29 % of the incidents are due to operational working conditions. Operational reliability would depend on a number of factors like human reliability, equipment reliability, equipment maintainability, process reliability. The defined risk influencing factors that affect operational working conditions are:

- Technical operability
- Dialogue
- Order systems
- Opening hours

Technical operability is equipment reliability, maintainability and the simplicity of using the system. Today Statoil operates with more than one planning and order system. D&W uses MDM SRM E-Catalog Purchaser/Contract Handler while O&M uses SAP, in addition when other firms are leased to do a job they may use other technical solutions than Statoil.

- **Compliance:** Compliance is connected to culture, competence and awareness of risk, but is defined as one since approximately 27% of the incidents are related to compliance. It is dependent on operations, procedures and support; if they were followed the incident often could have been avoided. Silent divagation is some of the reason; the operators' intentionally do not follow the procedures, maybe because they think it is an easier way to do things or it is just old habit. But also lack of awareness of the procedure is a problem. The largest factor here is that procedures were not followed.
- **Physical/Ergonomically conditions:** These conditions are directly connected to the planning of the logistic chain.
 - Documentation and certification
 - Priority
 - Installation storage area
 - Base storage area
 - Contracts
 - Supply vessel deck logistic
 - Other operations
 - Weather

The largest ergonomically condition is small and disordered work space, approximately 9% of the incidents is directly connected to ergonomically conditions.

5 Influence diagram

The logistic chain establishes the context of the problem and the groups of risk influencing factors give a small picture of what causes the incidents. But it is very difficult to see the total picture without a real graphical model. After studying incidents/accidents, the logistic chain and statistics an influence diagram for incident frequency is made to show a good graphical picture of all the risk influencing factors. This study has not involved research of how the consequences will be carried out during an incident, but a suggestion of how such an influence diagram for consequence could elapse can be seen in appendix E. In appendix D the RIF's in the influence diagram is explained.

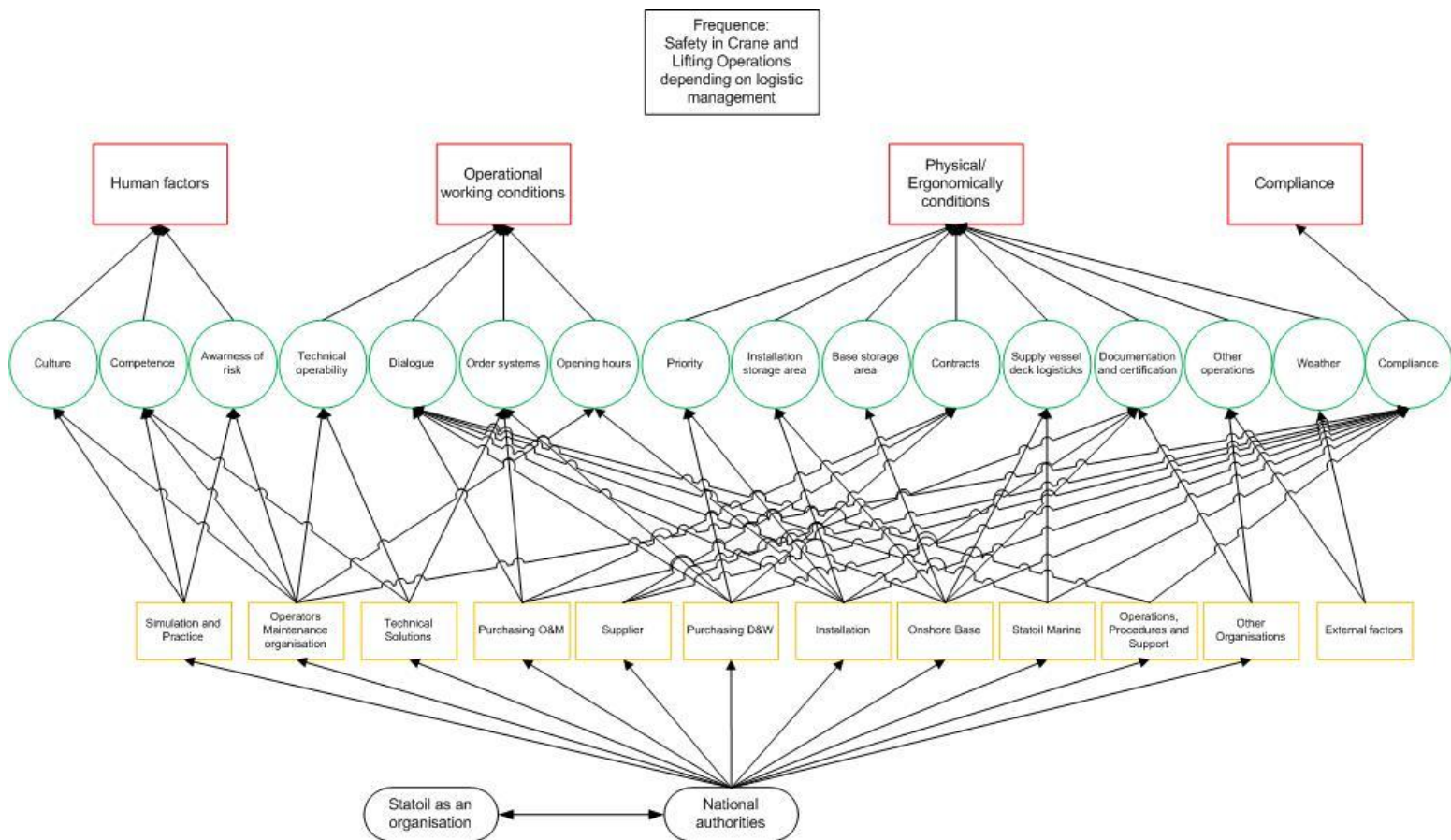


Figure 14 Influence diagram Frequency

6 Risk Picture

With the influence diagrams in place the causal factors can be evaluated in a BN. To do the analysis GeNIe is used. GeNIe is used to propagate the marginal probabilities when an evidence changes. It refers to itself as “a development environment for graphical decision-theoretic models”. (Decision Systems Laboratory, 2010) How to build a Bayesian network in GeNIe is described in (Decision System Laboratory, 2005-2007)

The risk model will be used to analyse and quantify the significance of the different risk influencing factors with regards to incident frequency.

6.1 Construction

The BN is divided into degree of severity of the incident, direct- and underlying causes to the incident, as described in chapter 4. This risk analysis is constructed with regards to the numbers in the statistic, this to give a picture of today’s situation.

6.1.1 Underlying causes

As described in chapter 3.4.1.1 it is difficult to specify the correctness of the conditional probabilities; the approach describes an interval for each probability to range between, and then evidence can be set as a number in this interval. The statistics have set this number for each of the underlying causes, so the main issue is to decide the range of the interval. The evidence of the interval will be used to calculate the direct causes. When changing the evidence new marginal probabilities in the incident node will be propagated. To make these calculations as easy as possible the chosen interval is only divided into four; Very Good, Good, Intermediate and Substandard, which makes the range large. The correctness of this decision will be debated in the discussion.

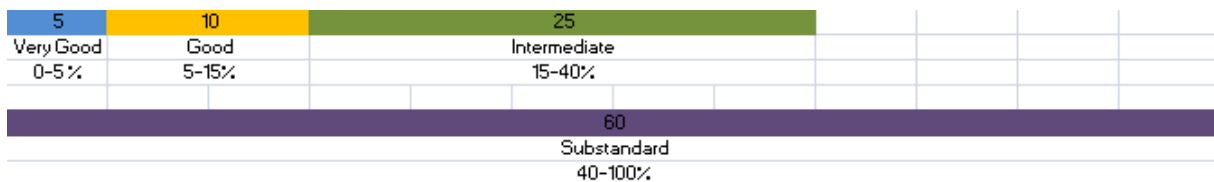


Figure 15 Interval

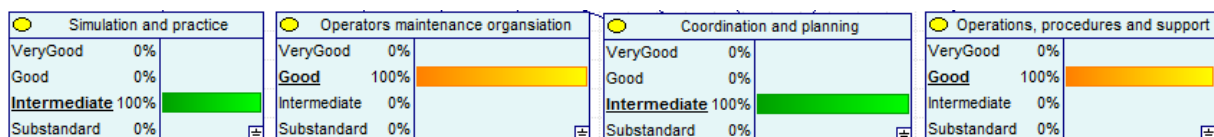


Figure 16 Underlying Causes today's situation

This is today’s situation with the chosen interval and evidence.

6.1.2 Direct causes

There are many explanatory BN structures for any given data set; therefore to calculate the direct causes the interval for the underlying causes will be used as a template.

- Decreased range:
 - From Very Good to Good: Multiply with a factor of 1.1
 - From Good to Intermediate: Multiply with a factor of 1.25
 - From Intermediate to Substandard: Multiply with a factor of 1.6
- Increased range:
 - From Substandard to Intermediate: Divide by a factor of 1.6
 - From Intermediate to Good: Divide by a factor of 1.25
 - From Good to Very Good: Divide by a factor of 1.1

The direct causes are divided into mishaps and no mishaps. From the underlying causes it is given that for example:

For human factors is:

- *Simulation and Practice* → **Intermediate**
- *Operators maintenance organisation* → **Good**
- *Coordination and planning* → **Intermediate**

-then it is given where to set the 35% influence (marked with red) for human factors, see figure 17.

The rest of the numbers can be calculated through the increasing or decreasing rang.

-If coordination and planning is set good, the mishaps are decreased with a factor of 1.25.

From good to very good a factor of 1.1.

From intermediate to bad it will increase with a factor of 1.6.

Simulation and...	Intermediate				Intermediate		
	VeryGood	Good	Intermediate	Substandard	VeryGood	Good	Intermediate
Operators mai...							
Coordination a...							
Mishaps	0.2545	0.28	0.35	0.56	0.32	0.35	0.434
NoMishaps	0.7455	0.72	0.65	0.44	0.68	0.65	0.565

Figure 17 Genle calculation of direct causes

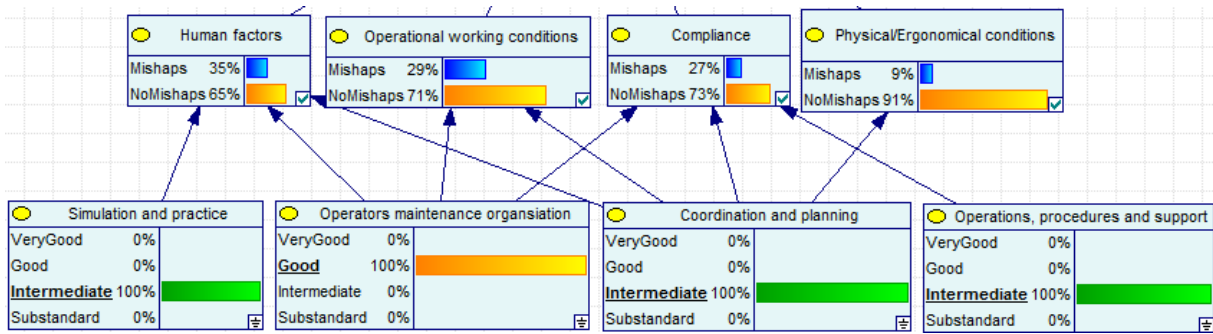


Figure 18 Underlying and direct causes with today's situation

6.1.3 Incident

The degree of severity in incidents follows the risk assessment criteria as explained in chapter 3.3. From statistics today's risk for an incident can be seen.

Table 1 Today's risk for an incident

Risk Area	% of incidents
Green	96,92622951
Yellow	1,43442623
Red	1,639344262

To calculate this some assumptions are taken. When there are no mishaps at all the chance for being in the green area is 0.9999%, yellow is 0.0001% which the normal offshore risk criteria (chapter 3.3) and red is 0%.

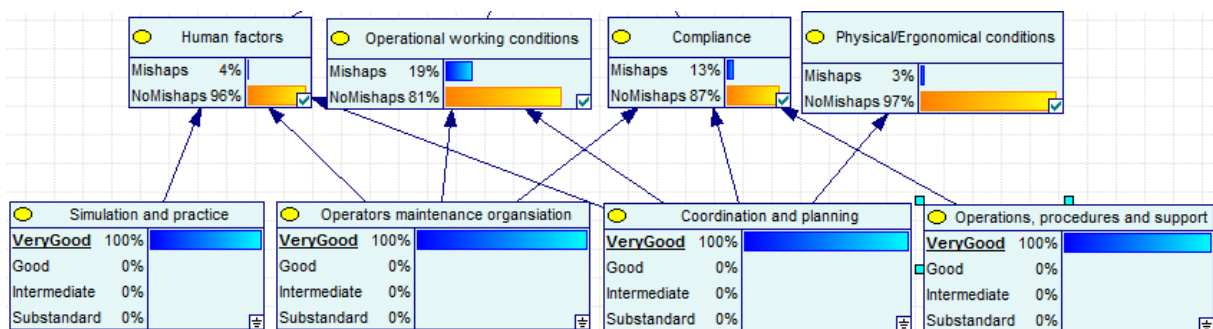


Figure 19 Direct causes factor for calculation of incident

The basis for the first calculations is taken for the chance of mishaps if all the underlying causes are set to Very Good. This is an approximation because that many combinations of numbers can give the same result, and since there is nothing to compare with; other installations, countries or companies.

Example:

Human factor → **No Mishap**

Operational working condition → **No Mishap**

Compliance → **No Mishap**

Physical/Ergonomically conditions-**Mishap** → Green: gives and reduction in 3% (marked with red) because it is a 3% chance of mishap (figure 19) if everything is very good for the underlying causes. Green=0.9999*1.03

Yellow=(0.999-0.9999*1.03)/1.03

Red=1-Σ

Human factors	NoMishaps		Mishaps		NoMishaps	
Operational working conditions	NoMishaps		Mishaps		NoMishaps	
Compliance	NoMishaps		Mishaps		NoMishaps	
Physical/Ergonomically conditions	Mishaps	NoMishaps	Mishaps	NoMishaps	Mishaps	NoMishaps
Green	0.815	0.8395	0.858	0.884	0.97077	0.9999
Yellow	0.1501	0.134	0.1211	0.1017	0.02828	0.0001
Red	0.0349	0.0265	0.0209	0.0143	0.00095	0

Figure 20 Genle calculation of incident

Then the same is done for the rest of the nodes. ⁴

If there are mishap in one of the other direct cause the reduction chance would change:

- Human factor: 4%
- Operational working conditions: 19%
- Compliance: 13%
- Physical/Ergonomically conditions: 3%

⁴ This is just an approximation to get the numbers in the wanted range.

This is not a real method just an approximation to get the numbers in the range wanted. The result was:

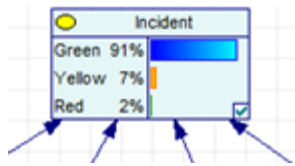


Figure 21 Risk for incident

The BN model shows a result that is more deteriorate than the real numbers. It is almost right in the red area but too high in the yellow. After some interpolation with increasing of the green area and decreasing of the yellow area a good result was found. The interpolation was done for the direct causes as well.

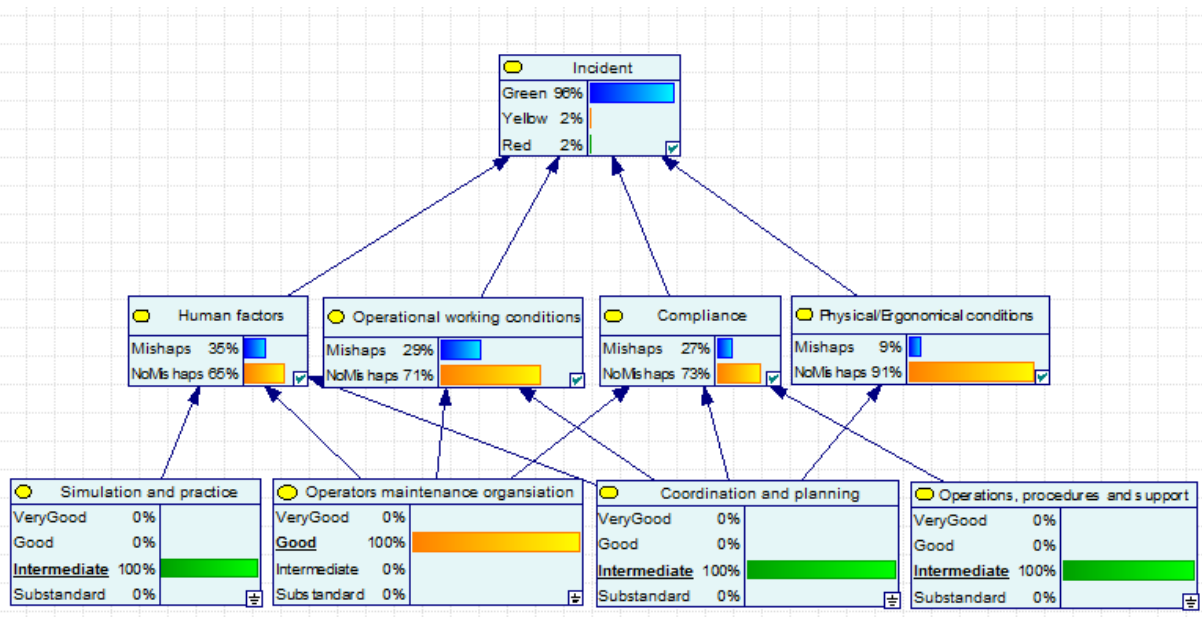


Figure 22 Today's Risk Picture

6.2 Analysis of potential risk improvement

To see where there is most potential for risk reduction each underlying cause is changed one by one (see appendix G). The one level change shows that there is most to gain with improvement of coordination and planning.

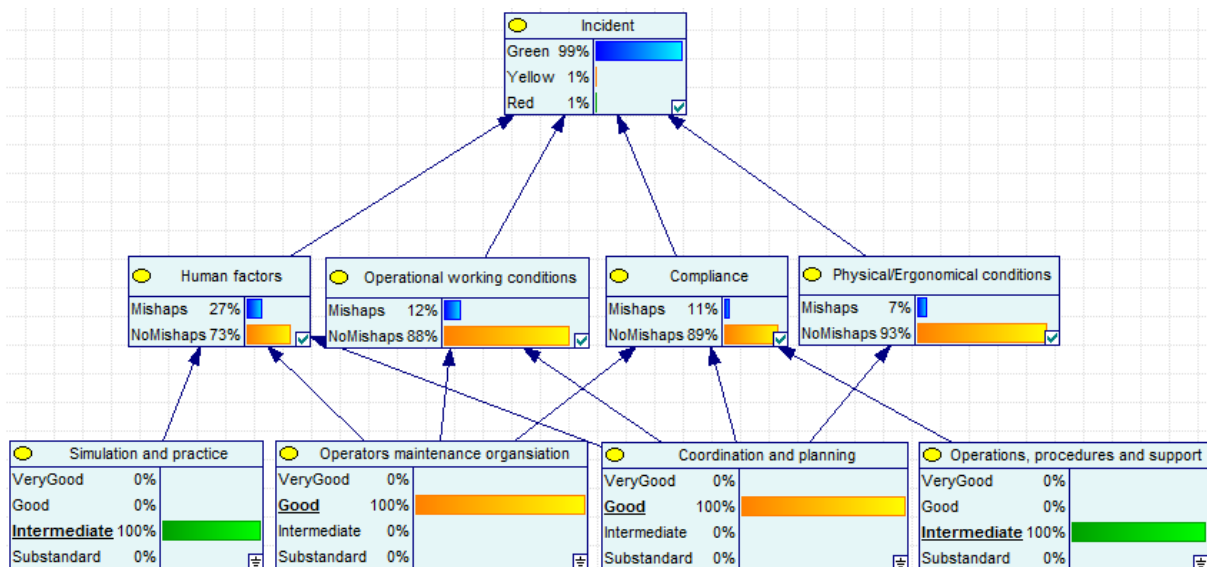


Figure 23 One level improvement that gives the best result

This is not unexpected since the coordination and planning influences all the direct causes. As can be seen from figure 23: 99% is in the green area and 1% is in both yellow and red, this is because Genle round the values up, so one cannot know the exact value but being in the red area is not acceptable so further analysis of the result must be performed. The operators maintenance organisation have in this risk analysis only one level of improvement, still an improvement in coordination and planning leads to better results than the operators maintenance organisation.

Simulation and practice and operations, procedures and support, change the degree of incidents to the same values; the green area is 97%, the yellow 2% and the red 1%. While a change in operators maintenance organisation leads to green area of 98%, yellow 1%, and red 1%, which is better than Simulation and practice and operations, procedures and support. This may be a result of that operators maintenance organisation affects more direct causes. One other thing to have in mind is that simulation and practice was the underlying cause of 38% of the incidents which is the highest percentage for an underlying cause. This means that the improvement in simulation and practice requires a much higher achievement than a change in coordination and planning or operations, procedures and support which were both approximately 24%. But if improving simulation and practice knowledge and awareness of the operations procedures and support would increase as well, and could therefore improve both the causal factors.

Just one improvement is not enough to decrease the red area to a wanted level. This requires more improvements in each level, but there is more than one possibility. There are many different optimizations that give the same result. The easiest way to achieve 0% incidents with severe degree red is by having a one level change in simulation and practice, operators, maintenance organisation and coordination and practice. If changing operations, procedures and support one level as well the

result will not change. This is most likely because operations, procedures and support only affect compliance which is also affected by coordination and planning and operators maintenance organisation.

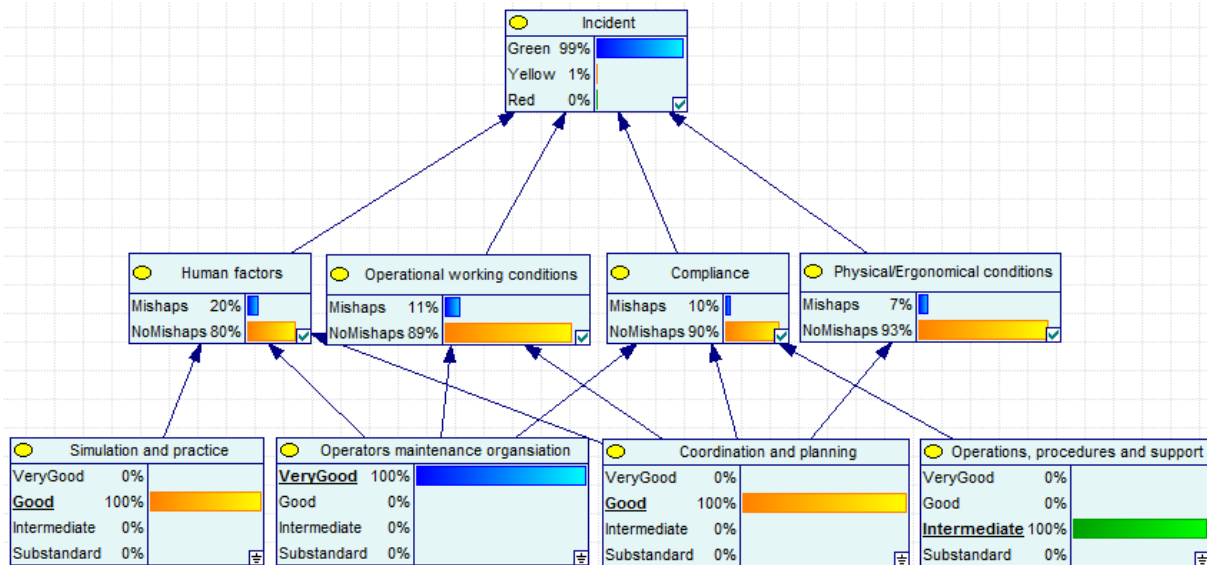


Figure 24 One level change in Simulation and Practice, Operators Maintenance Organisation and Coordination and Planning

A two level change in simulation and practice and coordination and planning will also give the same result (see figure 53), but because simulation and practice have such a high rate affecting the direct causes this will be harder to achieve.

One level change in operators maintenance organisation and two level change in coordination and planning can also be a solution (see figure 54), but this means that the coordination and planning must go from Intermediate to Very Good, which might take years to achieve.

Figure 56, 59 and 60 also shows way to achieve the same result, but this will also require a two level change in two or three of the underlying causes, as mentioned above this process will take a lot of time.

The best and least time consuming way to achieve 0% red will be to do one level change in simulation and practice, operators maintenance organisation and coordination and planning.

To get the yellow area as low as possible there is actually not needed to optimize all the underlying causes to very good, even though this is the safest way to do it. But this result can be achieved by fully optimisation of all simulation and planning, operators maintenance organisation and coordination and planning. Operations procedures and support is assumed to only affect as mentioned above compliance and is one out of three causal factors for this direct cause and simulation and practice and knowledge about the already excising operations, procedures and support is more important.

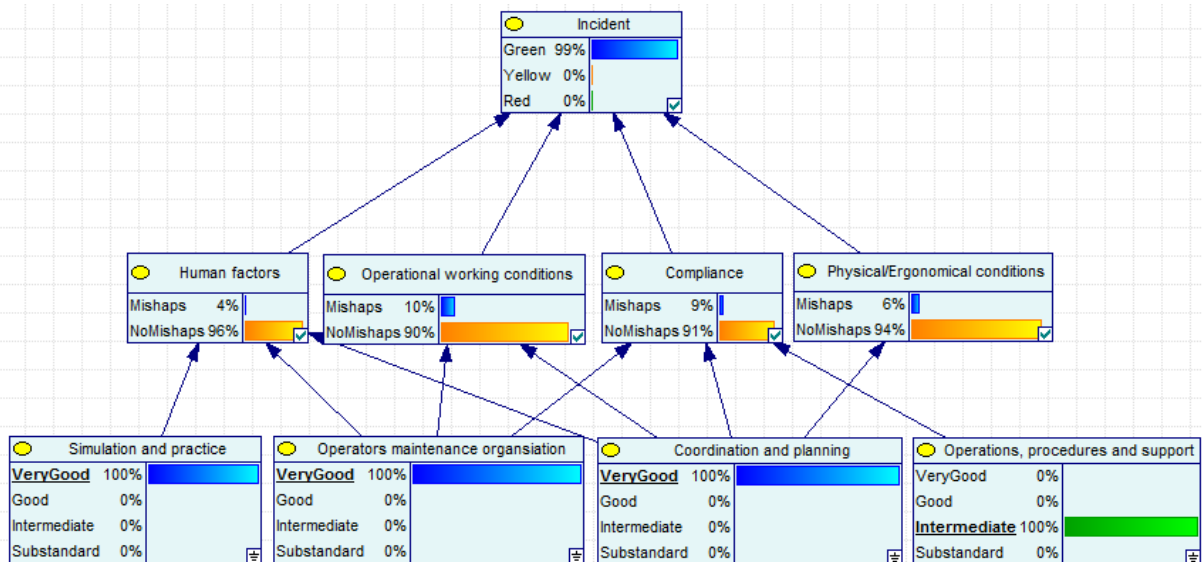


Figure 25 Two level changes in Simulation and Practice and Coordination and Planning and one level change in Operators Maintenance Organisation

This fully optimisation will require a lot from Statoil as an organisation. Therefore it can be recommended to start with improvement in coordination and planning first, and then continue with simulation and practice.

7 Measurements

With today's situation the risk for being in the red area is 1.64, this is unacceptable and risk reducing measures must be taken to reduce this probability. The yellow area is in the range of 1.43 which is not severe but it should be as low as possible so there is room for improvements. From the analysis of the potential risk improvements it could be seen that optimisation of coordination and planning affected the result most.

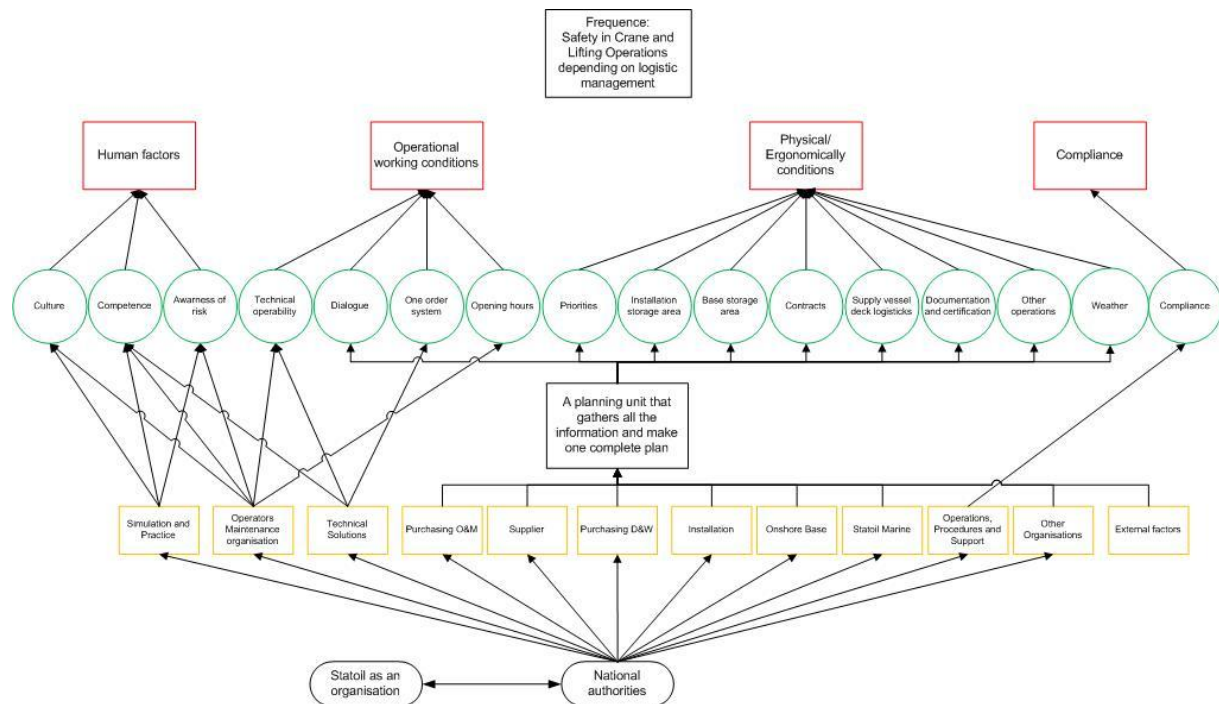


Figure 26 Influence diagram Frequency Measurements

Coordination and Planning: The easiest and most difficult thing to change in coordination and planning is the fact that every planning unit only sees their own unit, dialog between the units is almost non existing. This should be very easy to change. Meetings between the units could increase the degree of coordination. The best solution would be to have a superior unit, i.e. one person from each unit that should gather all the plans and make one comprehensive plan. These persons should gather maybe once a day and update each other on each planning process and find ways to coordinate the logistic. (Aasebø, 2011)

Not all parts of the logistic chain use the same planning and communication tool. This can lead to misunderstandings of which tasks that should be done by whom. Today SAP is the main planning tool, but in addition other tools are also used. MDM SRM E-Catalog Purchaser/Contract Handler is a very good planning tool and because of this it is under development part of SAP. But there also exist old versions of different tools, these tools could easily be removed, but this will require better training in SAP.

Lack of space characterises the storage area at the base, this leads to goods that may not be necessary at the installation are sent anyway; everyday meeting between installation and base are in transit. Automatic orders and bar codes should be optimised so that the system works properly. The

automatic orders should have a hold indicator so that in case of delays the order will not be sent to the supply base. An updating of the bar code numbers so that all information is available without all the documentation and certification, then all information about the goods could easily be sent to the supply vessel and installation right away. (Økland, Information received during Statoil meetings, 2010/2011)

Priorities are in some degree misused, the purpose is to use priority in case of installation shutdown. In case of installation shutdown the installation chief should know. Therefore the priorities should be requested by the installation chief. (SupplyVessel, 2011)

RFID is a tracking systems for load carriers that can say where the containers are; at the installations there is often difficult to track the goods, this can easily be done by RFID, in addition if something is delayed during transport this can easily be traced. (Interview, 2011)

A lot of empty containers for special backload are sent to the installations, a milling machine could be used at the installations, and then backload could be sent in normal containers. (Økland, Information received during Statoil meetings, 2010/2011)

The degree of utilisation of containers could be improved by modification of contracts. This is not an easy process because many of the contracts last for years, but when entering into contract this should be taken into consideration. It is also important that the right people are present to share their experiences. (Økland, Information received during Statoil meetings, 2010/2011)

Simulation and Practice: The simulation and training for especially crane operators seems to be good, and should be continued. But the lack of competence about other parts of the logistic chain and their problems and challenges seem to be a problem. Maybe a course where each part of the logistic chain presents themselves, their problems and challenges could inaugurate to a better understanding of the logistic chain.

Training in SAP is very much needed. Not only are different programs for planning used, different parts of SAP is also used. A standardisation of purchasing and usage of SAP should be implemented.

Operational working conditions: Equipment performance, opening hours, physical working conditions and organisational working conditions affect the ability to perform assignments. Failure in equipment is definitely the largest factor of conditions, which means that the maintenance operations need to be optimised. (Interview, 2011)

Operations, procedures and support: The procedures are generally very good, but not always followed. This might be a result of abundance of procedures. Procedures are very important, but they have to be specified in such a way that they are easily understood and easy to adopt/implement. During routine work a lot of the procedures are skipped to save time and frustration. Maybe more simulation and practice and not so many procedure operations beforehand could be a solution.

Many of these measurements are already in the process of being implemented into the organisation. More detailed about the measurements can be seen in appendix E.

8 Discussion

Communication of risk is a complex academic field. How can the description of risk be comprehensible and reach the intended audience? The way of performing risk assessment must be challenged. This is particularly true for the written form. The starting point must be – what is usable, meaningful and useful to the workforce?

Risk assessment should be up to date, stimulate thinking and improve collective and individual decision making. Rather than driven by regulatory concern, it should be an integral part of planning. Inspectors should assess the quality of the risk assessment by attending shift change tool-box talks or comparing written risk assessments against actual activity and thereby the competence and depth of the assessment.

In this assignment it has been performed a causal analysis with regards to the logistic of D&W and O&M. Through research an analysis has been performed and the result shows that better coordination and planning would decrease the degree of severity of incidents most.

The result is in accordance with expert judgment and is not surprising since coordination and planning was the underlying cause affecting most direct causes. Even though the result agrees with expert judgements, one must remember that all assumptions introduce possibilities of errors.

8.1 Statistical Significance

There are many ways of using and choosing statistic. One can never be too sure of a correct result without knowing the statistics thoroughly. This can be discussed as a subjective choice in every risk analysis. When looking into such material, most often the focus is “what went wrong?”; this can give an incorrect perspective on the operation. Generally the operations are successful without any kind of difficulties; another way of thinking could be to focus on “what makes an operation successful?”. This could turn investigations into something positive instead of a constantly negative focus.

In the hazard identification it is looked into incidents and accidents happened during crane and lifting operations in connection with D&W. The statistic was chosen by the author, but has the author the competence to choose important statistic; which was not explained further by anyone? If some statistics lack it may give a wrong picture on the results. And since it is only chosen with regards to operations connected to D&W it could have been good to use other statistics for evaluation of the result, one could have seen if the result was the same in other operations. It is also only looked into the Norwegian shelf and Statoil, to see the contrast it could have been good to look at different countries and different companies or not look at all the installations as one. It is very different culture and practices at the different installations; when the installations are far away from land there are indications of better planning routines. (Interview, 2011)

The statistic provides an indication of a reduction in incidents from 2002 till 2010, but it also shows an increase in incidents with red seriousness. Si hva red er og med red i parantes. The data material used for the calculation is only taken from one year. If one wants to look at the trend in statistic this material is too small. It will not be statistically significant enough; this will require at least ten years of statistic and it is an increasing trend of registrations of incidents/accidents each year, which means that the statistic picture can still change a lot. (Herrera I. A., Håbrekke, Kråkenes, & Forseth, 2010)

But on the other side there is registered approximately 260 000 inbound and outbound lifts the last year, and then it is not taken into account the 5-8 lifts in total within the installations. There is a certain risk in every lift and in this case it gives a good picture of today's situation. When working with the statistics the author grouped the different reasons. This grouping was done differently by Statoil and some of the reasons overlapped each other but was placed into different groups. Again the competence of the author is questioned; another way of grouping could have given a different result.

8.2 Model

A sequential model is used to carry out the analysis. The advantage with this type of model is that it is very easy to represent graphically. Graphical models are important because it makes people talk and think. The downside of this model is that it can be difficult to design complex socio technical systems. It also exist epidemiological models and systemic models, they were not chosen because:

- Epidemiological models are very difficult to represent graphically but it gives a basis for discussing the complexity of accidents that overcome the limitations of sequential model, which is good. But they are never stronger than the analogy they use, and are therefore very difficult to specify in detail. (Hollnagel, Department of Computer and Information Science)
- The systemic models advantage is their emphasis of that accident analysis must be based on an understanding of the functional characteristic of the system. It looks at the accident as a sudden incident; this means that an accident neither can be described as a causal series or a causal net, which means that a good graphical description is not possible. (Hollnagel, Department of Computer and Information Science)

For the sequential model a BNA was used. The BNA was carried out with the Aviation Safety Risk Model in mind. The ASRM is a very systematic, structured approach and it shows how to use BNA in a good way, but there are many other ways of carrying out such a risk analysis as well. Through the analysis the HSS3 have been used as a template for design of a graphical form of a tree or a network called influence diagram. It basically assumes that accidents and incidents can be described as a result of cause effect relations. The basic idea is that incidents and accidents can be explained by finding out what went wrong, which can be either a single or a composite event. (Herrera I. A., Håbrekke, Kråkenes, Hokstad, & Forseth, 2010) (Vatn, 2006) Then to find relationships between the RIF's the BNA is used.

There are several advantages for such a graphical model, it encodes dependencies among all variables, can be used to learn causal relationships, gain understanding about a problem domain and to predict the consequence of intervention, it can be used to combine prior knowledge and data, and it is an efficient approach for over fitting of data. (Microsoft, 1996)

The BNA is very controversy in a statistician eyes. Though statistic and experts have been used during the analysis, the approach can be accused for being very subjective. A statistician finds probability as the outcome of repetitive experiments, a mathematic finds the probability as a curve while a Bayesian defines probability as a degree of confident or certainty. So in many cases it can be accused for being subjective, but as Kaplan says:

“The key point here is that while probability is “subjective” in that it measures something internal, namely degree of confidence, it can be defined to be entirely “objective”, so that degree is determined totally by the evidence, and not by the personality mood. And the way that it is determined is through Bayes’ theorem” (Kaplan, 1997)

The meaning is that an evaluation will always be, to a certain degree, subjective, it is the way the result is used, and the way the experts are used that matters. The expert can either be asked “what is your meaning?”, or “what is your experience?”. When asking “what is your experience?” the answer will not be subjective any more. So therefore the author finds Kaplan to be right, and finds the Bayesian approach as subjective-objective.

There exist a number of sequential models that may have been chosen:

- **FTA (Fault Tree Analysis):** A typical representation of this is the fault tree. It expresses the relation between an unwanted event (Top event) and the causes of this event. It can be used to find the performance of components causing the Top event or to find the reliability of the barriers. This is modelled through logical gates which show us the relations. (Rausand & Utne, Risikoanalyse -teori og metoder, 2009) A fault tree could have been used to complete the analysis. But if a fault tree had been used the level of details would have been limited. The system is quite complex when it comes to numbers of RIF’s that can lead to accidents. It is also difficult all to include all the organisational factors, make a connection between them, and to find data for them. Therefore a Fault tree is not applicable in this context.
- **ETA (Event Tree Analysis):** A node in the sequence of events that may lead to the accident represents a specific function, task, or activity that can have two different outcomes, usually denoted “success” and “failure”. A node can either represent the function of a technical system or component, or the interaction between an operator and the process. (Rausand & Utne, Risikoanalyse - teori og metoder, 2009)
- **Bow Tie model:** The “Bow Tie” model has been accepted as a good mental model. (Vatn, 2006) There exist several models for the “causal analysis” and the “consequence analysis”. The most common is called MIMAH and has a “Fault tree analysis” on the left side and an “Event tree analysis” on the right. But it can also be an influence diagram for frequency on the left side and an influence diagram for consequence on the right. (Rausand & Utne, Risikoanalyse - teori og metoder, 2009)

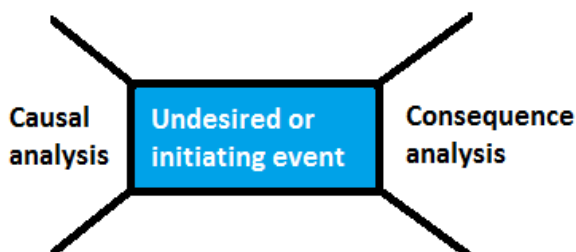


Figure 27 Bow Tie model

(Vatn, 2006)

- **FRAM (Functional Resonance Analysis Method):** Developed to provide a practical and effective approach to describe and analyse the role of performance variability in socio-technical systems; can be used for both accident investigation and safety assessment. (Hollnagel, Tveiten, & Albrechtsen, Resilience Engineering and Integrated Operations in the Petroleum Industry, 2010) As a systemic approach, the FRAM model replaces the traditional cause-effect relations by the principles of resonance. This means that the variability of a number of functions every now and then may resonate; reinforce each other and thereby cause the variability of one function to exceed normal limits. The consequences may spread through tight couplings rather than via identifiable and enumerable cause-effect links. The model seems to be very good and could have been considered, the only downside found is that it does not give a clear graphical picture. (Hollnagel, Tveiten, & Albrechtsen, Resilience Engineering and Integrated Operations in the Petroleum Industry, 2010)
- **HRA (Human Reliability Assessment):** Is a set of methods that describes the incorrect human action in the contexts of Probabilistic Risk Assessment (PRA) or Probabilistic Safety Analysis (PSA). The premises for HRA are that it must function within the constraints defined by PRA/PSA, and produce the human action probabilities that are needed by PRA/PSA. The accident sequence that is analysed by PRA/PSA is typically represented as an event tree; it is a need to know whether it is likely that an event will succeed or fail. (Hollnagel, Department of Computer and Information Science) Is not relevant in our case because of the need to know whether it is likely that an event will succeed or fail, and cannot account for the complexity of the assignment. (Hollnagel, Department of Computer and Information Science)
- **CREAM (Cognitive Reliability and Error Analysis Method):** Represent a second generation tool of the HRA, allowing for better analysis by abandoning the hierarchical structure of previous methods and providing better separation between objective and subjective error. It specifies how to link consequences and antecedents, this to explore the causal patterns. The primary feature are the ability to identify the importance of human performance in a given context and a helpful cognitive model and associated framework; usable for both prospective and retrospective analysis. (Hollnagel, Department of Computer and Information Science) (Marcae) There are many advantages with this model, it is used for: stand-alone analysis method for either retrospective or prospective analyses, as a part of a larger design method, as an HRA in the context of Integrated Safety Analysis or Probabilistic Safety analysis. It might have been used for our purpose, but it would have required a high level of resources, a lot of time and it does not put forth potential means by which the identified errors can be reduced. (Hollnagel, Department of Computer and Information Science) (Marcae)
- **MAIT (Marine Accident Investigation Tool):** Where originally developed for the railway industry, its principles and classification are derived from James Reason's⁵ organisational error model, and are therefore highly transferable across domains. It traces the human factor elements along both latent and active pathways to ten root organisational conditions: Training, Supervision, Communication, Rules and policies, Design, Planning, Pressures, Materials, Tools and equipment, and Maintenance. (Marcae) This method is based on classification and rating of acts after the accident has been looked into. This method could

⁵ James Reason, Professor Emeritus, University of Manchester, UK. A leading scholar on the field of organizational factors. (Reason, 2006)

also be a good approach to identify the RIF's, the only downside found is that it gives no graphical model. (Marcae).

As can be seen FRAM and MAIT could have been used for this type of analysis as well. Maybe it would have given another result; it might also be other models not mentioned here that could have been used.

8.3 Construction

When constructing the Bayesian Network there are a many uncertainties. The inability to handle continuous node variables accurately has been the main challenge of BN tools. When a BN model includes a node representing the number of faults found in a system, instead of just specify that the node ranges from zero to infinity, a way to break up this infinite range into manageable number of intervals have to be specified in advantage. The more intervals defined, the more accuracy will be achieved; it is a huge difference between 24% of the underlying causes leading to incidents and 38% leading to incidents, but these two are in the same interval, Intermediate, but the computational abilities complexity of more intervals will be extreme. Therefore only a range of four intervals were defined in the underlying causes. Another factor that can be criticised is that normatively Very Good should be set to 0%, but this will complicate the accomplishment of the calculations. But since the evidence is set to a 100% and it will lead to the numbers wanted, it will not in our situation influence the result in a too large degree. (Fenton & Neil, 2007)

Since this analysis is done with regards to statistic, the probabilities for the uncertainties are set as the statistic. This gives the picture of the situation today, and can therefore easily be used to find good ways to improve the situation.

The most difficult part of such an analysis is to set the numbers for the incident, because then there is no interval to further make use of, and there was no way to compare with other installations, companies or countries. The wanted result was known, but many combination of number could give this result. Therefore the same approach for calculation of the direct causes were used but instead of a interval all evidences were set to Very Good and then the numbers given in the direct causes could be used. This gave not the result wanted, therefore interpolation of the incidents and the direct causes were done until the wanted result appeared. This is certainly not an accurate approach, but the experts agreed with the result it gave; therefore it could be used for further analysis.

9 Conclusion

From investigation of the logistic chain, incidents/accidents and statistics there was found:

Underlying causes:

- Simulation and practice 38.5%
- Operators maintenance organisation 14%
- Coordination and planning 24.6%
- Operations, procedures and support 23%

Direct causes:

- Human factors 35%
- Operational working conditions 29%
- Compliance 27%
- Physical/environmentally conditions 9%

Incident:

- Green 96,93%
- Yellow 1,43%
- Red 1,64

When situations are at high risk (red), precautions must be taken straight away. The analysis shows that it will be most efficient to improve coordination and planning; the underlying case is reflected in all the direct causes and will affect all of them in a positive way.

Some measurements will affect coordination and planning easily.

- A lot of misunderstandings could have been avoided if everyone had been using the same technical system, SAP, for ordering and planning. To achieve this goal everyone must learn how to use the system, and use the same part of it. A group of planners from each unit should meet once a day and work together to make one plan and inform each other about changes.
- For the supply vessel and installation it would have been much easier if every documentation and certification were online, this could make their planning process much easier. Then plans of where the goods should be placed could be done before the vessel enters at the supply base and the installation would have had time to prepare better for reception of the supply vessel. This should be quite easy to implement since all goods should already have a serial number in SAP:
- The milling machine at the installations would also make things much easier, because then not so many containers would need to be shipped to the installations and space and money would be saved.

9.1 Further work

Suggestion for further work;

- Carry out thoroughly a cost/benefit analysis for the measurements.
- Further risk assessments of the measurements one on one not as a whole group.
- Clarify who is to be responsible for implementation and follow-up of the measurements

When the overall risk is reduced to an acceptable level the appropriate risk mitigation measures can be implemented. It is important to monitor the risks, have regular reviews of risk levels and ensure that risk analysis is updated when changes in activity or assumptions, i.e. a change of activity on the platform, or alterations that may lead to change in the level of risk on board. This information is important to include in preparation of new risk assessments and also contributes through the entire process.

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Appendix

A: Safety in the logistic chain

During crane operations and heavy lifts a lot of energy is involved. Falling objects can lead to serious injuries and material damage. Most incidents show that of securing, use of straps, wires and clamps and check on/off of pipes requires special attention. Loading/unloading should follow the rules in APOS and NWEA guidelines [chapter 3].

Large numbers of bulk products (for example chemicals, water, cement, and barite) are transported forth and back to the Norwegian shelf. These products may be of hazardous substance, and will therefore need a lot of documentation (see chapter 2.2 section 2. Delivery). A representative from the bulk supplier and vessel should assure full surveillance of hoses that are used for transfer of bulk. Equipment like hoses, approved quick release couplings and pipes shall be controlled and absorption material shall be available in case of leakage. Loading of bulk is described in NWEA [chapter 4]. Coordination of load-/unloading processes require good communication; different types of noise, bad routines for radio communication etc. can lead to misunderstandings and unwanted incidents. There should always be contact between loading base and vessel via radio communication (UHF/VFH). Communication guidelines are described in NWEA [chapter 2.3, 3.1 and 3.3.3].

Working personnel during loading/unloading operations should always use protective equipment. Employer is responsible for this to be available, but it is your own and your colleagues responsibility to use it

Securing of deck cargo during sailing may be a considerable safety challenge. Personnel that are working to secure cargo shall hold approved license from OLF. Securing of deck cargo is described in APOS [SCM02.01/04] and in NWEA [chapter 3.2.4 and 3.3.6].

When vessels operate in shallow water base operator and port authority shall inform the vessel about the depths of water and how to manoeuvre. Described in NWEA [chapter 3.1].

If there is bad weather the Statoil Marine and the vessel captain are in close contact reviewing if it is safe to continue operation as planned. The captain has the final say.

Statoil Marine gives the signal for the supply vessel to leave the base.

When the vessel is 500m from the installation it is serving it establishes communication. If other vessels are nearby the installation (500m), Statoil Marine tries to call them up and make them change their direction so that dangerous situations are avoided. When reaching the installation there is a safety zone of 500 meter radius from the installation. This zone should never be crossed without permission from the installation, the vessel must contact the installation minimum an hour before arrival. Described in Statoils Captains circular 01/2007, APOS [SCM03.02.12] and NWEA [chapter 3].

Dynamic positioning systems need to be tested before unloading operations can start.

Collision between vessel and installation can be dramatic both with regards to personal and material damage. Dynamic positioning is a tool that has reduced such incidents but they still happen. A minimum distance between vessel and installation within the safety zone is 10 meters, except with wind speeds above 40 knots and/or a wave height of 5 meters; then the minimum distance is 1x vessels largest with. With wind speeds above 35 knots and/or wave height above 4 meters, and if the machinery have to use more than 45% of the engine power to lie in position it is not allowed to be

situated at the windward side of the installation. This is described in APOS [SCM03.02.12], in NWEA [chapter 8.1 and 9] and OLF's Captains manual.

To avoid accidents during loading/unloading of the vessel, the load is placed at the vessels pursuant to sailing route and sequence of loading at the installation. Sometimes urgent needs arise and the loading/unloading process must differ from the plan; these urgent needs more easily create dangerous situations, especially with regards to pinch. Good planning from the installation is therefore required. APOS [SCM03.02.12] and NWEA [chapter 3.3.6].

Loading of return goods from the installation shall not happen before the vessel has achieved documentation about the cargo. The right precautions need to be taken, this because the cargo can be a danger to health and/or the environment. NWEA [chapter 3.2.5.3] and "Safety alert 1/2009".

A problem for the vessel near the installation is emissions from the installation. This leads to bad working conditions at the vessel, and the emissions may be hazardous for the health. To avoid this, warnings routines when the vessel is at the installation has been introduced, but if the vessel is exposed for such emissions it can stop the operation and leave the installation for the time being. APOS [SCM03.02.12] and NWEA [chapter 3.3.6].

Falling objects can lead to fatal incidents and accidents. To avoid this deck personnel on vessel and installation must control that there exist no loose objects during loading/unloading. APOS [SCM03.02.12] and Statoils Safety alert 01/2008 " Fall from elevation"

Coordination of loading/unloading depends on good communication between and internal at vessel and installation. APOS [SCM03.02.12] and "Safety alert 02/2008]

Chemicals that are to be returned shall be registered in advanced, marked, packed and documented. Health danger can be avoided by giving right information about the content of the shipment. NWEA [chapter 4].

Working personnel during loading/unloading operations should always use protective equipment. Employer is responsible for this to be available, but it is your own and your colleagues responsibility to use it.

(Logistikkportalen, Statoil, 2010)

B: Accidents from 2005 to 2010

26.04.2005: Oseberg B

One person got hit by a 600kg drill pipe which fell down from the pipe handling crane, while moving pipes on the Norwegian Installation Oseberg B (Hydro), and suffered major head damages. The direct cause of the accident was that a drill pipe fell from the magnetic yoke and hit a man in the head.

The Petroleum Safety Authority's investigation revealed that there was many breach of law. The underlying causes were:

- Insufficient directing of operations on the pipe deck
- Insufficient compliance of procedures for lift operations
- Insufficient training
- Technical weaknesses with the pip handling crane

13.01.2006: Ekofisk

One person was injured during positioning of a new engine exhaust system in a cement unit on Ekofisk (ConocoPhillips). The exhaust cooler (390kg) fell down and hit a person in the left leg. The unit is owned and operated of Halliburten and the injured person also worked there.

The investigation revealed breach of law by both ConocoPhillips and Halliburten:

- Deficient management on board the facility
- Deficient facilitation of maintenance on the cement unit
- Lack of competence with regards to mounting and the usage of temporary lifting equipment
- Lack of planning of the lift operation
- Lack of training in the ConocoPhillips procedure

11.05.2007: Scareboe 5

During installation of a 1300kg and 6 meter long hydraulic lift cylinder on a catwalk machine on the drilling arrangement Scareboe 5, one person got serious injured in the shoulder. After investigation the general impression was insufficient organisation and risk comprehension.

- Insufficient adaption of the work
- Insufficient risk identification
- Insufficient leadership during work
- Persons under hanging load

02.06.2007: Transocean Searcher

During transportation of a BOP on the movable arrangement Transocean Searcher failed the connection between the BOP and the elevating mechanism. The BOP with a weight of approximately 200 ton fell about one meter and was standing on the edge of the transportation carriage. The reason for the accident is most likely linked to an error during mounting of lifting equipment and riser section. No persons were injured.

30.06.2007: Stena Don

A hydraulic tool fell from storage position on drilling floor on the movable drilling arrangement Stena Don (Stena Drilling), which were about 5.5 meters. No persons were present when the accident happend.

04.07.2007: Kvitebjørn

A 13.6 meter long and 921 kg heavy drill pipe fell 26 meters from the grab-hook on the grab handling crane and down on a walkway on the Installation Kvitebjørn (Statoil). Luckily no persons were injured and no further material damage.

The investigation revealed many weaknesses and breaches of law. The derogations are related to failures of the crane manufacturer, National Oilwell Varco, and with the drilling contractor, KCA Deutag. At the same time Statoil has a great potential of improvement when it comes to their responsibility as operator.

On the operational area the conclusion was that the pipe stanchion was not activated and the communication between the crane operator and the installer was diffuse.

Technical weaknesses as absence of built in safety functions on the crane and the crane was not identified. In the user manual there was lacking danger and safety specifications, breaker indication for activation of the pipe stanchion in the user manual.

Other critical circumstances were among others that the crane operator was not formally or sufficient qualified for the assignment.

12.08.2007: Saipem 7000

One person fell over board and died during a lift operation on the lift arrangement Saipem 7000 (StatoilHydro). The last time an accident of death was registered related to petrol industry was in 2002.

The person that fell was a part of a work team of four, which worked together on a winch that was wounded on a hydraulic rubber. The rubber was connected from the winch to a pulley in the crane beam and down to the module.

The pulley was filibeg and it was and it was a tension in the rubber from the pulley down to the module, and a slack from the pulley down to the winch. While they were unsuccessfully trying to get the rubber loose a bend of the rubber was lying left on the winch Installation by the winch.

Probably the causality was hit by the rubber when it suddenly was tighten up, and fell approximately 30 meters down in the sea and drowned. During investigation PTIL found:

- Error in the design of the pulley arrangement.
- Insufficient design and risk assessment
- Insufficient evaluation of technology to reduce risk
- Insufficient risk evaluation and risk realization
- Insufficient distribution of responsibility and communication lines
- Insufficient delivery/communication
- Insufficient follow-up by operator

It is identified defects with both StatoilHydro and Saipem. StatoilHydro got a warning about injunction.

14.09.2007: West Epsilon

During a lifting operation on West Epsilon (med statoil som operator i brønn 16/2-3 nord for Sleipnerfeltet) several tones of heavy conductor casing fell over the drill bridge (drillerbrua) on the drilling floor. Two persons were sent till land with helicopter with smaller injuries.

The Petroleum Safety Authority Norway is doing a investigation, in addition the police have asked for assistance in their investigation.

18.09.2008: Troll A

During a lifting operation on Troll A (StatoilHydro) a steel beam went loose and hit a person. He was injured in the left hip, thigh and Installation leg. The accident happened during dissembling of an approximately 335 kg heavy steel beam. After the investigation the impression is that the operation was characterized by insufficient organizing, risk assessment and incorrect use of the crane. There are also shown that rules are broken and injunctions are set against StatoilHydro. Aibel has also got injunctions.

28.02.2009: Deepsea Bergen

One person was injured during pinching in breast and abdomen during work on an installation, Deepsea Bergen. He was squeezed between the crash barrier and the manipulator arm that was operated. Investigation is in transit.

09.05.2009: Troll C

During a lifting operation on the Installation Troll C (Statoil) a worker on deck was squeezed between a container hanging in a crane hook and the container barrier on the cargo deck. Bone fracture and smaller internal bleeding were the result of the accident but it could have been much worse. The result of an investigation showed that there was several rule violation.

- Insufficient control of the crane and lifting activity
- Insufficient planning
- Insufficient description and communication of roles and responsibility for the HSE coordinator/nurse
- Insufficient job description for the responsible of operational lifting operations
- Insufficient compliance of controlling documents for lifting operations

Injunction was given to Statoil.

06.06.2009: Åsgard

During a lifting operation a part of a riser (Åsgard), about 11 meter long and 1.24 tones fell about 12 meters over deck and hit the head and neck of a customer engineer. The injured lost consciousness for a while, but was not further injured. The drilling floor had also some damages, but the consequences could have been much worse.

Investigation shows that the riser was not fasten to the fasten equipment during the lift. Underlying causes for this is defects during construction and maintenance of the fasten equipment, training,

competence, organisation and accomplishment, supervision and breach of procedure. And lifts are not supposed to happen when personnel are under hanging load.

The concerning parts are after investigation given injunction. (Stena and FMC)

10.08.2009: Deepsea Atlantic

A lifting accident occurred at Deepsea Atlantic (StatoilHydro, Odfjell Drilling AS and Ofjell Well Services AS) when a seven tones heavy conductor casing fell approximately six meters down on the catwalk. No one was hurt, but one person was in the sealed off area. There was some material damage but the outcome could have been much worse. The reason for the accident was that some of the equipment was not probably locked during lifting.

The underlying reasons were:

- Defects during construction of the elevators
- Insufficient control and maintenance of the elevators
- No user instruction manual
- Weakness in the control system for HMS
- Insufficient control of the receipt
- Lack of the systems information of the transfer of experience and improvement
- Lack of competence
- Lack of planning, performing and risk assessment
- Insufficient leadership
- Lack of procedure
- Breach of procedure
- Insufficient procurement, control and usage of provisional equipment
- Insufficient follow up of the accident
- Statoil followed up in an insufficient way

The concerning parts are given injunction (Odfjell drilling AS and Statoil)

30.05.2010: Stena Don

A hydraulic tool with a weight of 790 kg fell on an unsecured area on the drilling area on board on the facility Stena Don. The tool was stored 5.5 meters above the drilling area and only secured with one chain in an eye bolt, which are not made for securing. No persons were injured and no severe damage on any material.

During investigation derogations have been found and improvements that can be made are:

- Technical solution from the supplier
- Documentation from the supplier
- Risk assessment of equipment that arrives the Installation
- Work procedures and explanations
- Supervision and inspection of the equipment.

(Petroleumstilsynet, 2010)

C: Interviews

The interviews were done at the supply base Ågotnes the 28.04.2011; they is in Norwegian and will be transcript that way.

- **Samtale med Bjørn Ågotnes: Materialkoordinator.**

Møte med Statoil Marin og de andre basene foregår kl 08.30 hver dag. Her gir man en oppdatering på vær, forespørsler fra installasjonene og status på båtene. Det er to båter som går fast i rute fra Ågotnes.

Flaskehalsler:

- Dårlig lagerplass på installasjonene. Mange rekvisisjoner som fører til at enterprisen pakker utstyr klar til seiling, men pga plassmangel på installasjonene kan ikke dette utstyret sendes ut, kun utstyr som virkelig trengs kan sendes ut.
- Plass:
 - Autobestillinger: Noen bestillinger er fast. Men pga usikkert værvindu kan båten ikke gå, leveransene fortsetter fordi om og plutselig ha man et lass med varer som blir stående på basen.
 - På installasjonene er det generelt dårlig plass. Båtene kommer med varer, noe er det plass til og man får losset opp noe, deretter må installasjonen rydde for å få mer plass, da må båten ta seg en runde, kanskje gå til den andre kranen. Dette fører til forsinkelser på andre installasjoner, kanskje er ikke alle installasjonene åpen hele døgnet og båten må dra til en annen installasjon først og losse av der. Da har den kanskje ikke plass til å ta med alt av retur, fordi den ikke ble kvitt det utstyret den skulle på den første installasjonen. Ofte har heller ikke installasjonene planlagt hva de vil sende tilbake.
- Generelt dårlig kommunikasjon og kommunikasjonsmidlene fungerer ikke optimalt. Ingen kommunikasjon mellom installasjon og enterprise fører til masse ekstra arbeid for materialkoordinatorene. Timer kan forsvinne fordi ingen finner bestillingen.
 - Bulk:
 - Blir innmeldt på mange forskjellige måter. B&B bruker vel og merke Laste og leie logg, og dette fungerer greit. Mye pga at man vet hva behovet her er. Når det gjelder drift er det mer vanskelig, de melder inn i Lotus Notes (hvis man er heldig), pr mail, pr telefon.
 - Krever ofte vasking av tanker (SAR). Dersom innmeldingen skjer tidlig kan det være mulig for båten å få vasket tankene før den kommer inn til land, slik at lasting kan skje med engang. Men ofte så har de med seg retur bulk og da må dette losses av først, deretter må tankene vaskes også kan man laste. Dette skaper forsinkelser.
 - Leveres av MI, Halliburton, noe av Swaier.
 - Installasjonene og leverandører har veldig dårlig kommunikasjon

Løsninger

- Møte mellom dekk (kapasitet og plass) og boring (utsyr ut og inn) hadde vært en god ide.
- Ha et fartøy liggende.

- Entreprisen burde konsentrere seg om neste dags last og ikke ekstra last
 - Prosedyrer og rutiner må endres, kan ikke bare hive på båten.
- Installasjonen må begynne å plukke selv hva de vil ha ut akkurat den dage, nå er det omtrent enterprisen som plukker.

Intervju Bjørn Jarle Nilsen: Senior konsulent innen sikkerhet.

Hva er ditt ansvarsområde?

- HMS stab for felles operasjoner (støttefunksjon).
- Koordinerer sikkerhetsarbeidet for alle forsyningsbasene. Leder granskninger.

Hva er ditt daglige gjøremål på jobben?

- Lede sikkerhetsarbeid, rådgivning, støtte.

Hvilke problemer er det du møter på?

- Kompetanse er et problem, samtidig er også lokal opplæring vanskelig fordi det er forskjellige krav på forskjellige steder.
- Premissgivere, leverandører, transportører og offshoreinnretninger har en utfordring med basens leveringstider, dette skaper stressfunksjoner og prosessen fordyres.
- Stilleavvik, feil måte å gjøre ting på som blir godtatt (Kultur). Feil påvirker sikkerhetsnivået.
- Man glemmer ofte å se helheten, hver installasjon er som et eget "land", utfordringen er å hente det beste fra alle. Løse farlige gjenstander, truck og kran. Usikkert last.
- Under løfteoperasjoner har mennesker en tendens til å ta på lasten; dette er last som veier mange tonn som et menneske ikke har mulighet til å flytte på uansett hvor mye de prøver. Dette kan skape farlige situasjoner og klemulykker. Egentlig burde menneskene stå på god avstand fra lasten under operasjonene.
- Spesielle operasjoner går bra fordi her er man oppmerksom, rutinearbeid derimot.
- Tidspress noe man pålegger seg selv.

Prioritet B?

- Trengs, men jo flere jo mer ringvirkninger. (daglige drift)

Kan dette unngås?

- Stort forbedringspotensial på planleggingen.

Er informasjon du gjerne ville hatt som du ikke får?

- Stilleavvik.

Hvordan tror du dette kan løses?

- Kompetanse og trening.

Hvordan tror du man kan øke ledig dekkareal offshore på installasjonen?

Tiltak som er gjort?

- Synergi, dybdestudier, granskninger og analyser brukes mye tid på, her finner man årsaker og tiltakene som kommer er direkte fra årsakene. Læretiltak er et eksempel på dette (kurs).
- Korrekt lokal opplæring, passe på å ikke bli påvirket av kultur.

- Det pågår prosesser der sterke bidragsyttere ikke er med. For eksempel ved kontraktsinngåelser er basen og kontraktsoppfølger ikke med i prosessen.

Hvilke tiltak har vært suksessfulle og hvilke har feilet?

- Feilet: Dersom noe har skjedd, har man ikke reagert med engang; dette har ført til at man ikke har vært oppmerksom på trender. (for eksempel stor mengde påkjørsler med truck)
- Suksess: Læretiltak (begynte jobben med dette i 2000 har vært implementert siden 2006, samlet bransjekrav)

Hvilke tiltak mener du/dere burde vært gjort?

- Mer helhetlig samarbeid med relevante bidragsyttere.
- Tydeligere på arbeidsprosesser.

Hvilke samhandlingsløsninger bruker dere?

- Læretiltak (var tre la til fem)

Intervju med Kjell Olav Lokøy: Senior konsulent innen logistikk

Hva er ditt ansvarsområde?

- Leveranse og leverandøroppfølging

Hva er ditt daglige gjøremål på jobben?

- Standarder, revidering (for eksempel: Z015).
- Bindeledd mellom de forskjellige basene. Representerer alle basene.
- Oppfølging av utstyr frem til basen.
- Prosjekter, dersom utstyr går utafra andre havner enn baser, så ivaretar han basens interesser.

Hvilke problemer er det du møter på?

- Kommunikasjon, problem med erfaringsoverføring/tilbakemelding, vanskelig å nå alle.
- Kontrakt med noen, leie inn noen - elektronisk, når ikke riktig person, gjør at det blir vanskelig å få gjort ting på riktig måte etter APOS, spesielt hvis de er innleid. Man får ikke tilbakemelding.
- Kontraktene er ikke gode; de som har utarbeidet de har ikke kompetanse.
- Kontrakten må komme frem til de som skal gjøre oppgaven.
- Hendelser, avvik pga noe er gått ut som ikke skulle gått ut, får ikke erfaringsoverført dette.
- Mange forskjellige løsninger på teknisk avdeling.
- Møter tar for masse tid.
- Lite erfaringsoverføring i boring og brønn, man utnytter ikke at man er et stort selskap.
- For mange i logistikkjeden som mangler kompetanse.
- Historikk og rutiner er fortsatt et problem.
- It-systemet er utdattert; fungerer ikke opp imot de styrende dokumentene.
- Man skal følge de styrende dokumentene etter sin jobb, men problemet er å vite hva er jobben; hvilken del av APOS er det man skal etterleve?
- Man kjenner ikke it-systemene godt nok.
- B-prioritetene er pga dårlig planlegging, de installasjonene som ligger langt vekk klarer dette fint. Dersom selskapet representant for B-prioritet hadde gjort sin jobb, hadde ikke dette vært noe problem.
- Den største risikoen er at man ikke etterlever krav.

Intervju Vibecke Van Den Berg: Logistikk konsulent

Hva er ditt ansvarsområde?

- Mellomlagring, reoler og KPI

Hvilke problemer er det du møter på?

- Dårlig kommunikasjon med BFA
- Dårlig planlegging fra BFA
- Plassmangel, hvor skal mellomlagrings materiale lagres?
 - Noen ganger blir det ikke gitt beskjed.
- Når er behovet, utsettelse
- APOS har dårlig brukervennlighet.
- Man burde vært flinkere offshore til å tømme containere, en lagringscontainer kunne vært en løsning, verre med bulk. Bulk krever nedvasking av tanker og lignende, krever derfor mer planlegging.
- Containerfyllingsgraden er bedret.

Hvordan tror du dette kan løses?

- Møter med installasjon og BFA vil hjelpe, dette kommer.

Hvordan tror du man kan øke ledig dekkareal offshore på installasjonen?

Tiltak som er gjort?

- Communicator (internt samtaleredskap som alle data på Statoil har) er til stor hjelp
- Containerfyllingsgraden er bedret.

D : Statistic

An overview of the statistic obtained from analysing information registered in Synergi for crane and lifting operation incidents connected to drilling and well at fixed installation are given. (Statoil, 01.01.2010-01.01.2011) Figure 28 is divided into incident:

- Condition- a state that could easily have ended with personal injury but did not happen.
- Attempt-an almost injury.
- Injury.

It can be seen that the number of incident Condition has decreased, it was lower in 2002 and 2003 but this is most likely just because of better registration routines in the last years. The incident Attempt has decreased overall, but from 2009 till 2010 it increased, while incident Injury has varied to some extent. It is difficult to say something about the trend since the focus on registration has increased the last years.

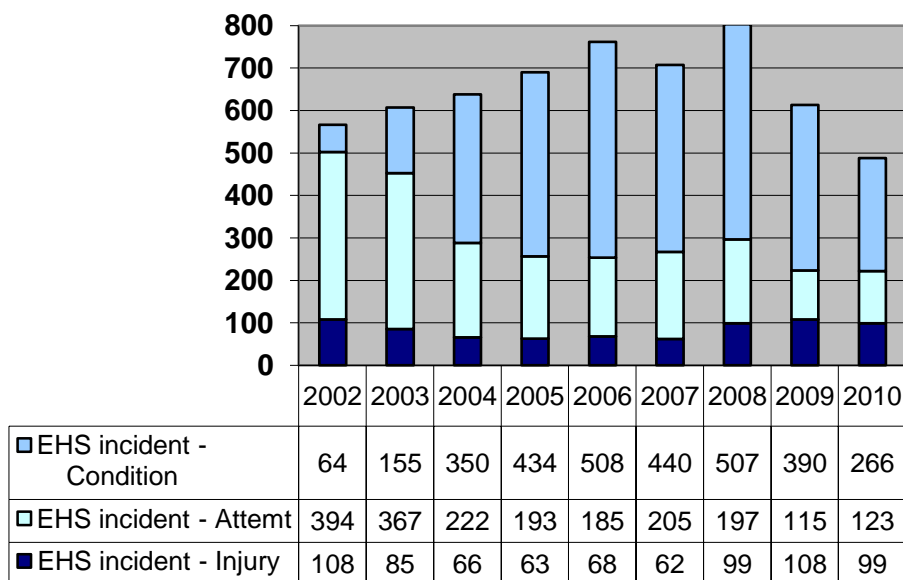


Figure 28 Incidents divided on incident

Figure 29 shows the incidents divided on risk areas for incidents on fixed installations connected to D&W operations. It can be seen that the green and yellow area has decreased over the years but the red area has increased, which means that there is room for improvement.

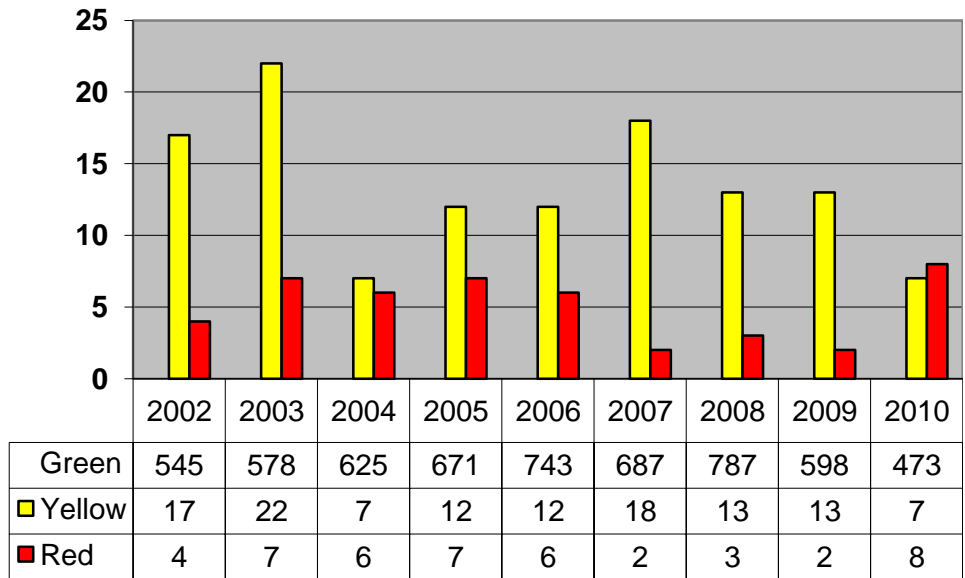


Figure 29 Incidents divided on risk areas

If looking at figure 28, it can be seen that number of injuries are 99, from the figure 30 it is only registered 13 injury types. This means that in figure 28 they have registered all types of injuries also those who do not need treatment; like bruises and finger cuts etc. From figure 30 it can be seen that there have been no death accidents, and no serious personal injuries since 2007. The rest of the colons are quite stable, but have decreased to some extent.

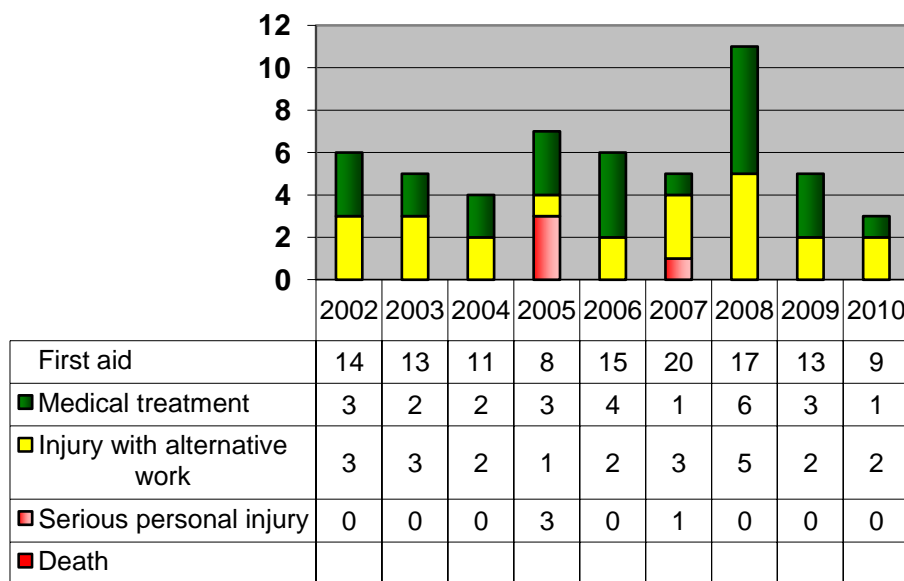


Figure 30 Incident divided into seriousness

Causes

To further understand the underlying causes of the incidents/accidents statistic must be examined.

Table 2 Numbers affecting Crane and Lifting Operations 2010-2011

Numbers affecting Crane and Lifting Operations 01.01.2010-01.01.2011	
Supply Calls	11 712
Supply Laytime	33 571
Extra Calls	215
Extra Laytime	1 879
Waiting on platform [hrs]	3 434
Inbound lifts	129 772
Outbound lifts	128 564
Total number of priorities, drilling	2883
Total number of priorities, well	475
Total number of priorities, operation	1543
Total number of priorities, project	405

Table 4 shows the number of supply calls and lifts, and also which department that inquire most priorities. The drilling department is the one with most priorities, almost twice as high as operations. Well and project are both quite low. The number of supply calls is 11 712 and the total number of priorities is 5306 it means that in 45% of the supply calls there will be a priority. It also shows that the number of inbound lifts at the installation is slightly larger than the number of outbound. The total number of lifts each year is approximately 260.000 lifts, and then the fact that the container is moved up to 5-8 times not taken into consideration.

For comparison statistics from 2008-2010⁶, it can be seen that the number of supply calls, extra calls, lifts have increased, priorities are at the same level. This is just to see if there is any trend, but it seems like only reporting has become more important. This statistic will not be used further.

Table 3 Numbers affecting crane and lifting operations 2008-2010

Numbers affecting Crane and Lifting Operations	07.2008-07.2009	07.2009-07.2010
Total number of supply calls	8 357	10 414
Total number of extra calls	80	194
Total number of outbound lifts	100 482	112 876
Total number of inbound lifts	100 814	114 501
Total number of priorities, drilling	Not given	2 643
Total number of priorities, well	Not given	377
Total number of priorities, operation	Not given	1 322
Total number of priorities, project	Not given	325

(Økland, Information received during Statoil meetings, 2010/2011)

The graph below describes number of accidents caused by crane and lifting operations compared to all accidents in Statoil. This shows that above 14.3 percent of all serious personal injuries are connected to crane and lifting operations.

⁶NB! The statistic from 01.2010-01.2011 is overlapping 07.2009-07.2010.

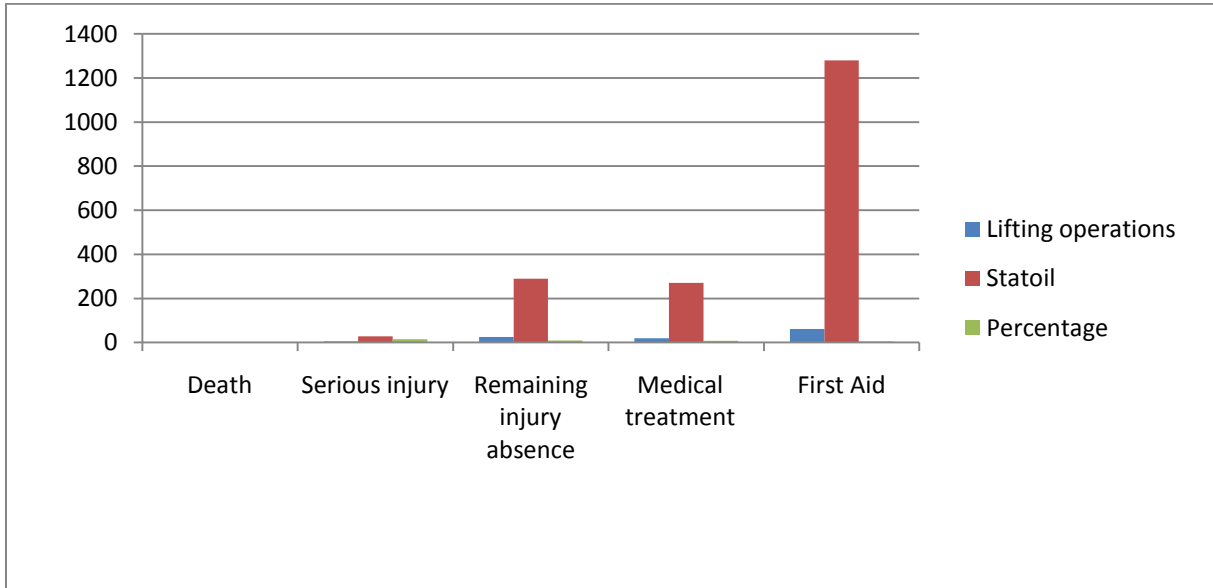


Figure 31 Percentage of crane accidents versus all accidents in Statoil

Underlying causes:

Underlying features are important but often not so obvious. Statoil has defined several underlying causes leading to incidents. In this thesis they are grouped into four underlying causes.

Table 4 Underlying causes

Underlying causes	
Simulation and practice	25
Operators maintenance organisation	9
Coordination and planning	16
Requirement/procedures/support	15
Total	65

Simulation and Practice: Simulation and practice is a great way to learn about risks and how to tackle certain situations. It is very important that every part of the logistic chain has a comprehension for the next, this seem to be a big problem in the organisation.

Simulations and practice will increase the level of awareness and the level of the operator's competence. It can also contribute to make the operators more aware of what is happening during a lifting operation, what dangers there are, and what can be done ahead to decrease this risk. Lack of risk awareness, not enough knowledge about rules and regulations and comprehension of what the next part of the logistic chain needs, seems to be the factor that should have increased relevance during simulation and practice. From the statistical calculations 38.5% of the direct causes of an incident are related to lack of simulation and practice.

Table 5 Simulation and practice

Simulation and practise	
Insufficient risk comprehension of the hazards	12
Lack of risk evaluation before the assignment	6
Earlier experience not taken into consideration	4
The assignment was not discussed beforehand	2
Changes not correctly executed	1
	25
	38,5%

Operator’s maintenance organisation: Support from the organisation is very important to get the operators to comply with the procedures; it shows that the organisation care about their crew. It seems like the operators maintenance organisation is rather good, but need to focus more on follow-up and maintenance of equipment. From the statistical calculations 14% of the underlying causes of an incident are related to lack of support from the operator’s maintenance organisation.

Table 6 Operators maintenance organisation

Operators maintenance organisation	
Technical failure because of lifetime (old)	3
Lack of follow-up	2
Defect during building	2
Known defects not repaired	1
Insufficient delegation	1
	9
	14%

Coordination and planning: Today the coordination and planning is done by many different units and with different technical solutions. The planning process is initially done in both O&M and D&W with a long term perspective, but since D&W’s need emerge more suddenly they follow up their plans more closely and make more often changes in transit. The whole chain has a common understanding of superior goals related to production, HSE and costs, but each part only sees their own goals. This leads to sub optimization and worse conditions for the next part in the chain. D&W know that their needs are always prioritized because of their important role in production, which has in some scenarios lead to misuse of the prioritising. The division of the planning activities, planning tools and lack of communication leads to many different plans and difficulties in coordination and cooperation. The plans are not coordinated enough or flexible enough to deal with other than some environmental variations; coordination requires both information processing and communication across different units.

Coordination and planning can be divided into:

- Technical solutions
- Purchase O&M
- Supplier
- Purchase D&W
- Installation
- Onshore base
- Statoil Marine
- Other organisations
- External factors⁷.

To change this trend the information processing has to increase in the organisation, where the planning tools is the lateral link of the information sharing process. Statistic shows that the largest factor of coordination and planning is lack of work preparation. From the statistical calculations 24.6% of the direct causes of an incident are related to lack of coordination and planning.

Table 7 Coordination and planning

Coordination and planning	
Unsufficient job preparations	8
Incorrect shipment/delivery/reception	3
Shipment not satisfactory inspected.	2
Important information not communicated.	1
Not used enough time to prepare the assignment	1
Not used enough time to do the assignment	1
	16
	24,6%

Operations, procedures and support: It is worked a lot with procedures and support during operations, APOS cover almost all the work processes, but one of the largest factors leading to accidents is breach of procedures. From the statistical calculations 23% of the direct causes of an incident are related to defective or not followed operations, procedures and support. Procedures are mainly set to secure safe operations.

Table 8 Coordination and planning

Operations, procedures and support	
Defective procedures	8
The working party did not follow the procedures	7
	15
	23%

⁷ External factors like weather could have been an own underlying cause, but since weather reports are given continually, this is a part of the planning procedure.

Direct causes:

Direct causes are the main factors triggering an incident/accident.

Table 9 Direct causes

Direct Causes	
Human factors	241
Operational working conditions	199
Compliance	186
Physical/Ergonomically relations	60
Total	686

Human factors: Knowledge about human factors can give an understanding of what leads to human failures. From a statistical point of view, arbitrarily actions are not the reason for human failure, but a series of out of control conditions. (Petroleumstilsynet, 2010) . Human factors are very much dependent on simulation and practice; with good and often simulation and practice the operators should be able to foresee unwanted incidents. It is also related to the operators' maintenance organisation, which is related to culture. Human factors can be divided into:

- Culture
- Competence
- Awareness of risk

These three factors are dependent on each other and are therefore considered as one. From statistics it is shown that approximately 35% of the incidents are due to human factors. The largest factor is lack of attention and considerations regarding risk, other common factors are equipment/material used incorrectly.

Table 10 Human factors

Human factors	
Lack of attention	161
Ignorance of other moments or risk	34
Incorrect use of equipment	16
Incorrect equipment used	8
Behavior not adapted to the surrounding environment	8
Lack of weather considerations	7
Incorrect use of material	2
Work on equipment without necessary measurements	2
Not precieved signals	1
Failure in the energy supply	1
Worked on the wrong equipment	1
	241
	35%

Operational working conditions: Operational working conditions and human factors affect each other, but the operational working condition will be more dependent on technical solutions, equipment and the surrounding working environment. One example of an operational condition that can lead to the human factor awareness of risk is tiredness; the operators on both installation and supply vessel are working on shift, and the workers at night are often more unaware than at day. The crew’s ability to perform its assigned tasks requires good environmental working conditions. The operational working condition is dependent on maintained equipment, physical working conditions and organisational working conditions. The most common incidents because of operational working conditions are due to equipment failure or bad design. Approximately 29 % of the incidents are due to operational working conditions. Operational reliability would depend on a number of factors like human reliability, equipment reliability, equipment maintainability, process reliability. The defined risk influencing factors that affect operational working conditions are:

- Technical operability
- Dialogue
- Order systems
- Opening hours

Technical operability is equipment reliability, maintainability and the simplicity of using the system. Today Statoil operates with more than one planning and order system. D&W uses MDM SRM E-Catalog Purchaser/Contract Handler while O&M uses SAP, in addition when other firms are leased to do a job they may use other technical solutions than Statoil.

Table 11 Operational working conditions

Operational working conditions	
Failure in equipment	106
Incorrect design	52
Not sufficient protective measures	17
Insufficient marking	9
Used defect equipment	9
Safeguarding system out of order	4
High temperature/noise	2
	199
	29%

Compliance: Compliance is connected to culture, competence and awareness of risk, but is defined as one since approximately 27% of the incidents are related to compliance. It is dependent on operations, procedures and support; if they were followed the incident often could have been avoided. Silent divagation is some of the reason; the operators’ intentionally do not follow the procedures, maybe because they think it is an easier way to do things or it is just old habit. But also lack of awareness of the procedure is a problem. The largest factor here is that procedures were not followed.

Table 12 Compliance

Compliance	
Procedures not followed	112
Equipment not properly secured	35
Lack of information	16
Lack of protective securance	14
Deliberate action	6
Deliberate action	2
Wrongly use of protective equipment	1
	186
	27%

Physical/Ergonomically conditions: These conditions are directly connected to the planning of the logistic chain.

- Documentation and certification
- Priority
- Installation storage area
- Base storage area
- Contracts
- Supply vessel deck logistic
- Other operations
- Weather

The largest ergonomically condition is small and disordered work space, approximately 9% of the incidents is directly connected to ergonomically conditions.

Table 13 Physical/Ergonomically relations

Physical/Ergonomically relations	
Place of work tight/not adapted properly for the assignment	21
Lack of order at work place	11
Lack of consideration for other assignment	10
Sudden movement in installation	10
Lack of visibility	3
Slippery foundation	3
Place of work/storage over-complex	2
	60
	9%

E: Frequency Risk Influencing Factors

1. Level RIF's

Culture

Definition	Culture consists of the ideas, customs and art produced by a particular society.
Description	<ol style="list-style-type: none"> I. In this scenario it is culture by the workers that is interesting. Here culture can be very dangerous and is often reflected in silent divagation. Silent divagation is the acceptance of breach of rules and regulations. As been seen looking into former accident breach of rules and regulations often is the main reason for an accident. (Interview, 2011) II. It also seems like many people in the logistic chain, especially in the drilling department at the installation, has a need to dominate, without any perspective of what this behaviour lead to. (SupplyVessel, 2011) III. Every part of the logistic chain only sees their own assignment and what they need, not the needs of the next part in the chain. (Nygård, 2010) IV. It seems like the human being often lays pressure on themselves. Time pressure is one of these problems, almost every human wants to do a job as good and efficient as possible. This leads to self made pressure to do the job quickly, which may lead to dangerous situations. (Interview, 2011)
Measurement	<ol style="list-style-type: none"> I. Silent divagation is hard to change, because this is one thing that is accepted. Simulation and practice may change this. (Interview, 2011) II. To prevent the people at the installation to dominate to some degree; Statoil Marine is suppose to do all the communication between installation and supply vessel; this is not entirely the custom jet, but is suppose to be. (Nygård, 2010) III. To change the culture of "<i>see only their own assignment</i>" a comprehension of the logistic chain is needed; a course where every part of the logistic chain presents their assignment, problems and challenges. IV. Self made pressure is like silent divagation very hard to change because it is self made.
Group of direct causes	Human factors
Comments	The culture in a part of an organisation is often a reflection of the culture higher in the organisation. It is important to do these measurements in a way that the operators feel that they are appreciated

Competence

Definition	The ability to operate in a safe and efficient way.
Description	<p>The competence is dependent on certain factors:</p> <ul style="list-style-type: none"> • Personnel competence; licensing of engineering staff, recurrent training, certificate of apprenticeship. Not all operators have the licence required and the training has different demands at different places. • Attitude • Individual psychological and physiological factors; if the operator is under stress or has a bad emotional state he should not be doing the operation. Physical factors can be hunger, illness, etc. • Organisational working conditions that influences the ability to perform assignments and the attention of the workers; like working schedules, access to necessary equipment, health and safety regulations, hotel facilities, food, resting shelters, clothing, etc. • Procedures
Measurement	Simulation and practice.
Group of direct causes	Human factors
Comments	

Awareness of Risk

Definition	To perform a safe operation under safe conditions is the knowledge of awareness of risk.
Description	<ol style="list-style-type: none"> I. To know when to stop an operation is just as important as to do efficient work. (Økland, Information received during Statoil meetings, 2010/2011) II. A human factor seems to be the “need” to touch the containers when they are to be placed at the installation deck or the vessel deck. This is very dangerous and can lead to pinch injuries. (Interview, 2011) III. When an operator defines an assignment for routine work, accidents more easily happen; if the assignment is not normal procedure the operators are more aware. (Interview, 2011)
Measurement	Simulation and practice
Group of direct causes	Human factors
Comments	

Technical operability

Definition	The technical operability requires good design and maintained equipment.
Description	Equipments performance, its functionality and reliability.
Measurement	Maintenance
Group of direct causes	Operational working conditions
Comments	

Dialogue

Definition	Dialogue is communication or discussion among groups. To understand each other during an operation can be crucial. But meetings before operations can be just as important as during. Planning of operations is very important; that every party involved understand their assignment and the others assignment.
Description	<ol style="list-style-type: none"> I. The reason for many accidents seems to be missing dialogue between the operators at deck and the crane operator. Many accidents seem to be because of lack of communication. Before an operation there a safe job analyses and a meeting should be completed, but if the operation is characterised as routine work, some do not look at these meetings as important. (Interview, 2011) (Petroleumstilsynet, 2010) II. Not all parts of the logistic chain use the same planning and communication tool. This can lead to misunderstandings of which tasks that should be done by whom. (X2X Maritime og Statoil ASA, 2010) III. The communication between D&W and O&M is almost non excising. O&M have a certain degree of understanding what D&W does at all time, but D&W have no thought about what O&M is doing. (Aasebø, 2011)
Measurement	<ol style="list-style-type: none"> I. The routines should be competed regardless the degree of difficulty of the assignment. (Økland, Information received during Statoil meetings, 2010/2011) II. The same communication tool should be used for all assignments. III. Communication between O&M and D&W: There should be a person in each team that has the superior responsibility. These persons should gather maybe once a day and update each other on each planning process and find ways to coordinate the logistic. (Aasebø, 2011)
Group of direct causes	Operational working conditions
Comments	

Order Systems

Definition	<p>SAP: Systems Applications and Products in Data Processing. Module based program that contains accounting, economics, sales and distribution, purchasing and inventory management, logistics, maintenance, production and personnel management.</p> <p>MDM SRM E-Catalog Purchaser/Contract Handler: Is a notes tool that is used for call-off, coordination and follow-up/trackin og D&W shipments until it is reached the installation.</p>
Description	<ol style="list-style-type: none"> I. Many different order systems: <ol style="list-style-type: none"> a. MDM SRM E-Catalog Purchaser/Contract Handler is used by D&W for orders and purchasing. The program works very well for D&W, but it is not used for backload (even though it has a very good system for it) and it is not a part of SAP. This makes it difficult for the base that shall have an overview of all the goods and planning of: reception, storage, technical services, SWIRE, rute planning and loading/unloading. This may lead to prioritising/reorganizing of goods, because of space

	<p>issues on the supply vessel. (Aasebø, 2011)</p> <ul style="list-style-type: none"> b. Bulk (Cement, water, chemicals and barite): In APOS it is said that bulk should be ordered 48 hours beforehand in SAP. Bulk is ordered in many ways; through MDM SRM E Catalog Purchaser/Contract Handler or an old version of this, through phone or mail. This makes it difficult to keep track of the orders. (Ågotnes, 2011) c. Service: Leasing of equipment or personell requires a special PO called service order. There ecist no procedure on preenrolment for need of transport. The equipment is delivered at the base, and one hopes that it will sail with the next supply vessel. A problem with leased equipment and personell is that the personell that should use the leased equipment want to be sure that the equipment is at the installation before they arrive. This lead to more equipment for storage at the small spaces at the installations. (X2X Maritime og Statoil ASA, 2010) d. Material number: It seems to be a problem to order through material number. In moste cases the purchasing agent receives a request about specification from the supplier, or he is not sure of what he receives. (X2X Maritime og Statoil ASA, 2010) e. Bar Code: All goods are marked with a bar code, but this is not used. And there is no function in SAP that shows what is on its way to the base, what is received, how it is packed or other relevant logistic information. This means that purchasers have to do surveys in SAP to see if the goods have arrived at the base. (Økland, Information received during Statoil meetings, 2010/2011) f. Automatic orders: The problem with automatic orders is that if there is bad weather or any other unwanted situation that leads to a delay, the automatic orders just keep going. This will lead to an accumulation of goods at the supply base; which will try to get the goods offshore. At the installations offshore it is even more crowded, and to fit a container there can be very difficult. This is more a problem for O&M than D&W. D&W have between 0-60% automatic orders⁸, they are in very close contact with the suppliers at all time; have to relase the purchase order in SAP before it is sent. (Interview, 2011) (Økland, Information received during Statoil meetings, 2010/2011) <p>II. SAP (X2X Maritime og Statoil ASA, 2010) :</p> <ul style="list-style-type: none"> a. Large system, high entry level. b. SAP is used by many different companies and has a standard appearance. If there is a extra device that Statoil want to implement in SAP, all the other companies have to agree to get this extra device. And it is very expensive. This is the problem with standardisation. c. Not every part of the chain works in the same part of SAP. There are numbers of ways to use SAP and if not everyone is using it the same way miscommunication and misunderstandings can easily occur. d. If D&W equipment is delaide, the suppliers have to notice the purchaser by phone or mail. There is no annunciating system in SAP that can do this. Generates additional work and makes it difficult to keep track of the goods.
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⁸ This is not the wanted target.

	<ul style="list-style-type: none"> e. The date for delivery is not consistent in SAP, today the purchasers vary between the wanted date for delivery offshore, delivery at the base or at the supplier. This is a source for delays.
Measurement	<ul style="list-style-type: none"> I. Many different order systems: There should be one order system: SAP. All orders should go through SAP; old systems that are still in use should be removed. This will result in less confusion and a system that is easier to control. <ul style="list-style-type: none"> a. A new MDM SRM E-Catalog Purchaser/Contract Handler in SAP is under development, and a trial shall be implemented this summer. (Aasebø, 2011) b. Bulk: c. Service: d. Material number: e. Bar code f. Automatic orders: There already exists a hold indicator. This indicator should be implemented on automatic orders for O&M and be a function of weather. (Økland, Information received during Statoil meetings, 2010/2011) II. SAP: <ul style="list-style-type: none"> a. Should be used in a standard way; this requires similar training opportunities for all the staff. b. Same as a. c. This must be decided and announced to all purchasers.
Group of direct causes	Technical operability
Comments	

Opening hours

Definition	The time when the installation or base is open.
Description	<ul style="list-style-type: none"> I. The base has generally very strict opening hours. This makes demands for the suppliers to have goods within a certain time horizon. This is a problem because the transport can be delayed by traffic or other uncertain incidents. (Økland, Information received during Statoil meetings, 2010/2011) II. The installation can be open 24/7 or only at day. The installations open only at day have to be prioritized before the 24/7 installation. This makes constrains when planning the rout for the supply vessels, and if there are delays there can be a problem to deliver the goods within the time horizon. (Ågotnes, 2011)
Measurement	This is difficult to change because of demands from national authorities etc.
Group of direct causes	Operational working conditions
Comments	

Priority

Definition	Some goods have a higher priority than the rest, if shutdown of production is at risk, goods to the installation to prevent this situation will have priority.
Description	<p>I. The problem with priority is that it is misused. The installation chief is not required to sign the priority, which means that anyone at the installation can do it. This leads to many bottlenecks in the supply chain; the goods may not be within the time for reception at the base, the supply vessel will have to wait, this means delays for the other installations etc. This is okay if there is really a chance for shutdown, but many cases have shown otherwise. (SupplyVessel, 2011)</p> <p>II. Equipment not owned by Statoil, but leased for an operation is often expensive. There exist no procedure on pre-enrolment for need of transport. The equipment is delivered at the base, and one hopes that it will sail with the next supply vessel. Therefore the equipment just suddenly shows up. It is supposed to arrive before 10.00 the day of dispatch. Since the equipment is so expensive it is often prioritised. This means that other equipment may be set aside and have to wait for the next supply vessel. Floating installation has higher prices for leased equipment than fixed, so they are the first to be prioritised. (Aasebø, 2011)</p>
Measurement	The chief at the installation have to sign the priority. (Ågotnes, 2011)
Group of direct causes	Physical/Ergonomically conditions
Comments	

Installation Storage Area

Definition	Installation storage area is the area where something is kept till it is needed. The characteristics of the deck location, space, layout is very important for functional installation logistic.
Description	<p>I. Overview:</p> <p>a. The installation storage area is often very over-complex. The containers are stored at different parts of the installation and there is too little room for storage, which can lead to a number of extra crane operations (5-7 extra lifts per load carrier). (Økland, Information received during Statoil meetings, 2010/2011)</p> <p>b. The deck operators are responsible to have an overview of where the containers are placed, what equipment that has bordered the installation and are always on the lookout for empty containers, to release space. This is controlled by personal involvement in lifting operations, but there exist no plan for this without a plan and with different people working at the installation, this is a hard assignment. Containers are marked at the roof, but other load carriers do not have this marking and can therefore be difficult to identify. (X2X Maritime og Statoil ASA, 2010)</p> <p>c. There is no registration of received goods in SAP, but the purchasers are often contacted through mail, phone or they follow up the cargo through VTMS. (X2X Maritime og Statoil ASA, 2010)</p> <p>II. Backload:</p> <p>a. Enrolment of backload from the installation shall happen</p>

	<p>before 10:00 the same day as the supply vessels departure from the base. Often the installation has more backload or is not finished with the completion of packing when the supply vessel reaches the installation. This can lead to delays. (X2X Maritime og Statoil ASA, 2010)</p> <p>b. The supply vessels do not get any information of how big the load carriers are, this makes it difficult for the supply vessel to bring with all the backload. This can lead to difficulties with space on the installation as well. The backload can also be dangerous goods or have other requirement for placement; this can be a problem for a fully loaded supply vessel. (SupplyVessel, 2011)</p> <p>c. Today empty SAR containers for special backload are sent out to the installations. This means that empty normal containers are not used at all; which requires extra space for both the normal containers and the SAR containers. (Økland, Information received during Statoil meetings, 2010/2011)</p>
Measurement	<p>I. Overview:</p> <p>a. It is important that the cargo area is well designed for safe and efficient lifting operations and equipment logistic. But this must be done during construction. (Økland, Information received during Statoil meetings, 2010/2011)</p> <p>b. RFID can help the deck operator to have a better overview of the containers. (Interview, 2011)</p> <p>II. Backload:</p> <p>a. The procedures for backload should be followed.</p> <p>b. There should also be a function in SAP which tells what type of load carriers that are to be sent back.</p> <p>c. A milling machine should be installed at the installation so that SAR containers become unnecessary to a certain degree, and backload goods can be cut and filled into big bags and put into normal containers. (Økland, Information received during Statoil meetings, 2010/2011)</p>
Group of direct causes	Physical/Environmentally conditions
Comments	

Base storage area

Definition	The characteristics of the storage area at land.
Description	Lack of space characterises the storage area at land. When a need is postponed and the cargo is on its way, it has to be storage somewhere. At the base a lot of cargo is already stored and it is difficult to find extra storage space. (Interview, 2011)
Measurement	Better communication with the installation to plan their operations. (Interview, 2011)
Group of direct causes	Physical/Environmentally conditions
Comments	

Contracts

Definition	A binding agreement between two or more parties.
Description	<p>I. The problem with the contracts is that many of the suppliers are to pack the goods, they pack the goods in large containers and the degree of utilization is very low. The reason why they Statoil let the suppliers pack the goods is because then the suppliers are responsible for the goods until it reaches the installation. 70% of the carrier's weight is the carrier itself. (Økland, Information received during Statoil meetings, 2010/2011) This means that the load carrier utilization is not optimized. This is a consequence of the contract between the suppliers/subcontractor and Statoil. This means that the equipment requires more transport and storage space than needed.</p> <p>II. The purchasing unit enter into contract with suppliers without involvement from the people that need the goods. (X2X Maritime og Statoil ASA, 2010) (Interview, 2011)</p>
Measurement	<p>I. Modification of contract.</p> <p>II. When entering into contract only the people from the purchasing unit is there, the people involved with the operations concerning the contract should also have something to say. The purchasing unit for D&W and O&M should cooperate so that their equipment can be packed in the same containers. (Interview, 2011)</p>
Group of direct causes	Physical/Environmentally conditions
Comments	

Supply Vessel Deck Logistic

Definition	The logistic regarding transportation of equipment from onshore base to offshore base at the deck of a supply vessel.
Description	<p>I. Deck logistic (SupplyVessel, 2011):</p> <p>a. The logistic on the deck of the supply vessel is critical for an efficient loading/unloading process. Information regarding what offshore base and what goods that should go off and on the supply vessel first is critical for the logistic planning of the deck. This is influenced by:</p> <ul style="list-style-type: none"> • Weather, specially which direction the wind is blowing (creating waves). • What installation needs supply first? • Backload: Is often not reported or ready from the installation. • The size of the goods is not defined, which is a problem for deck space. <p>b. It is a large problem for the installation’s crane operator that he does not know where the goods is placed at the supply vessel before the supply vessel arrives at the installation. These problems escalate with bad weather and not all cranes can be used.</p> <p>c. Today the shipper in cooperation with the base decides where on the vessel goods shall be placed. This is based on where the installation most likely want their goods. Badly placed goods at the vessel can lead to extra work for the crane operator at the installation:</p> <ul style="list-style-type: none"> • Relocation of goods at the vessel. • Goods placed “wrongly” at the installation. • The supply vessel must be moved between the cranes at the installation. • Difficult to unload bulk and deck cargo at the same time. <p>II. Equipment that is leant has no procedure to inform about needed transportation; which means that they just hope that there is room on the supply vessel.</p>
Measurement	<p>I. The size and type of goods should be defined in the information given to the captain of the supply vessels so that they can more easily plan the deck layout. If the crane operator could join in to decide where the goods should be placed it can result in:</p> <ul style="list-style-type: none"> • Decreased lay time for the supply vessels at the installation. • Minimize number of lifts at the installation. <p>(SupplyVessel, 2011)</p>
Group of direct causes	Physical/Environmentally conditons
Comments	

Documentation and Certification

Definition	The goods should have a packing notification which should contain contract- and order number, description of the shipment, name on the consignor and recipient. Also certifications, EHS- data sheets and hazardous goods consignment note should follow the goods. It also should tell where the goods should be delivered so that sorting at the base could be easily done. (Logistikkportalen, Statoil, 2010)
Description	Every part of the logistic chain requires documentation, as we saw under the Logistic chain, Delivery; a lot of paper is required for the processes to go without any problems and delays. This leads to a huge paper mill. If some of the documentation is incorrect and the goods are placed wrong; it can have serious consequences. All the goods are marked with a bar code, this code can give all the information needed, but it is not used. (Some of this problem is described under different systems and problems with material number). When information of how a shipment is packed, size, weight and how many load carriers there are, is a problem to receive. This leads to delays when loading/unloading of supply vessel and installation. (Økland, Information received during Statoil meetings, 2010/2011)
Measurement	If the bar code system had been followed, a lot of papers and delays could have been avoided. (Økland, Information received during Statoil meetings, 2010/2011)
Group of direct causes	Physical/Ergonomically conditions
Comments	

Other Operations

Definition	Surrounding activities, which can affect the Installation operations.
Description	
Measurement	
Group of direct causes	Physical/Environmentally conditions
Comments	

Weather

Definition	The climate is affecting the crane operation
Description	Examples of influencing weather can be: wind, snow, ice, waves, rain, lighting, darkness, fog, temperature changes, and polar lows. For example the waves can be too high for a lifting operation from the supply vessel to the Installation. The temperature can be so low that the hydraulic oil has to be warmed up before activation of the crane.
Measurement	
Group of direct causes	Physical/Environmentally conditions
Comments	

Compliance

Definition	Doing what you are asked to in a certain way so that procedures are followed.
Description	Compliance is connected to culture, competence and awareness of risk, but is a very is defined as one since approximately 27% of the incidents are related to compliance. It is dependent on operations, procedures and support; if they were followed the incident often could have been avoided. Silent divagation is some of the reason; some of the operators' intentionally do not follow the procedures, maybe because they think it is an easier way to do things or it is just old habit. But also lack of awareness of the procedure is a problem. Approximately 27 % of the accidents are related to compliance. The largest factor here is that procedures were not followed. (Statoil, 01.01.2010-01.01.2011)
Measurement	
Group of direct causes	Compliance
Comments	

2. Level RIF's

Simulation and Practice

Definition	Simulation is a tool to learn by doing.
Description	Simulation is a great way to learn about risks and how to tackle certain situations. Simulations and practice will increase the level of awareness and the level of the operator's competence. It can also contribute to make the operators more aware of what is happening during a lifting operation and what dangers there are. (Økland, Information received during Statoil meetings, 2010/2011)
Effects on other RIF's	Culture Competence Awareness of risk
Comments	At Statoil they send their crane operators and co-workers to simulation and practice every 3. year.

Operators Maintenance Organisation

Definition	The way the operator's organisation or maintenance approved organisations plan and carry out the maintenance of the technical equipment used to carry out crane and lifting operations, to the extent that this has a direct or indirect influence on operator's safety.
Description	It is a fact that maintenance is necessary for safe operations. A good maintenance program will increase the operational time and prevent equipment to be broken. Most importantly it will ease the planning process, and decrease urgent consignment. The focus on maintenance and safety must be prioritized high in the organisation to show the "workers on the floor" that they and what they do affects the system. Maintenance can either be scheduled or unscheduled. Scheduled are tasks specified on the maintenance program or manual, while unscheduled are outside the plan. (Herrera I. A., Håbrekke, Kråkenes, & Forseth, 2010)
Effects on other RIF's	Culture Competence Awareness of risk Technical operability Opening hours Compliance
Comments	In this diagram I have counted this RIF as the ones that also set the working procedures.

Technical Solutions

Definition	The technical support solutions that Statoil provides.
Description	A good and simple technical solution support will lead to less difficulty with ordering and planning.
Effects on other RIF's	Competence Technical operability Order systems
Comments	

Purchasing O&M

Definition	Is in conversation with the O&M unit at the installation, and purchases goods from the suppliers.
Description	
Effects on other RIF's	Dialogue Order systems Contracts Compliance
Comments	It is mainly D&W who uses leased equipment.

Supplier

Definition	Supplies the offshore/onshore bases with equipment needed.
Description	The supplier affects how the equipment is packed and freight to the onshore base. Is it packed in a big container or small, high or low? How the supplier has packed the element affects the logistics on the Installation. Green logistics is also an important element for the offshore companies. (Økland, Information received during Statoil meetings, 2010/2011)
Effects on other RIF's	Contracts Documentation and certification Compliance
Comments	

Purchasing D&W

Definition	Is in conversation with the D&W unit at the installation, and purchases goods from the suppliers.
Description	
Effects on other RIF's	Dialogue Order systems Priority Contracts Compliance
Comments	

Installation

Definition	Controls the installations activities, from logistics to the offshore hotel service.
Description	The offshore base contributes to the logistic on deck, they have to know where equipment and make it easy to get to necessary tools. It also influences the opening hours of the Installation. Is it a 24/7 Installation or is it only open at day? The vessel operator and the offshore base has to cooperate to get the equipment effectively and safe forth and back offshore-land. (Økland, Information received during Statoil meetings, 2010/2011)
Effects on other RIF's	Dialogue Opening hours Priority Installation storage area Documentation and certification Compliance
Comments	

Onshore Base

Definition	Receives, handles, controls, stores and sends out cargo.
Description	The onshore base is responsible for the logistics on the harbour. Other suppliers send cargo to the onshore base, and they bring it further to the offshore base. Some of the cargo from the supplier is spot checked so that they do not send out broken equipment. The cargo sent out to the Installations should be controlled, good packed and easy to handle. (Statoil; Ågotnes, 2010/2011)
Effects on other RIF's	Dialogue Installation storage area Base storage area Supply vessel deck logistic Documentation and certification Compliance
Comments	

Statoil Marine

Definition	Controls the vessels from land.
Description	
Effects on other RIF's	Dialogue Supply vessel deck logistic Compliance
Comments	

Operations, procedures and support

Definition	Procedures should cover all aspects of lifting operations.
Description	<p>I. The procedures are relatively good. Often it is a fact that had the procedure been followed then the accident would not have happened, the problem is when the procedures not are followed. The dilemma seems to be the awareness of the procedure.</p> <ul style="list-style-type: none"> • ADR/RID • NORSOK standard Z-015r3 (Soon to be a new revision.) • Statoils pakke- og merkeveiledning • OLF 091 • OLF 116 • OLF 054 • OLF 093 • OLF Kapteinshåndbok • OLF Master's Manual • Statoilspesifikke vedlegg til NWEA og OLF Kapteinshåndbok • ISPS Declaration of Security • ISPS Guidance • NWEA Retningslinjer • NWEA Statoilspesifikke retningslinjer • NORSOK standard R-003N • Safe Job Analysis (SJA) • APSO • IEATA <p>II. Key Performance Indicators. Is the goal to reach for all the different units in the logistic chain; the goals can be efficiency, punctuality or profitability. The KPI often lead to sub-optimization, which leads to problems for the next part of the chain.</p> <p>(Logistikkportalen, Statoil, 2010) (Aasebø, 2011)</p>
Measurement	<p>I. Simulation and practice</p> <p>II. The KPI's should be made for the whole chain or removed.</p>
Effects on other RIF's	Dialogue Compliance
Comments	http://logistikkportalen.no/ To read more about the different procedures see Appendix A

Other Organisations

Definition	The way external organisations etc, plans and carries out tasks that can influence the crane operation, to the extent that this has a direct or indirect influence on safety of the crane operation.
Description	
Effects on other RIF's	Documentation and certification Other operations
Comments	

External factors

Definition	Suddenly incidents that require change of plan.
Description	Can be commands from other departments on the installation or other installations or weather.
Effects on other RIF's	Other operations Weather
Comments	

3. Level RIF

National Oil and Gas Authorities.

Definition	The effect the national authorities have on: Safety regulations and design standards Requirements on crane design and manufacture Simulations and practice Certification and licensing of personnel Working conditions Responsibility of cargo Metrology and Communication Service
Description	
Effects on other RIF's	All the risk influencing factors expect external factors
Comments	The international and national rules are much the same. In Norway the rules and requirements for safe operations are very strict; therefore I have not taken the international rules as a RIF.

Statoil as an organisation

Definition	The way Statoil is organised and how they work out their work procedures.
Description	Statoil as an organisation is very dependent on the authorities, therefore are the two RIF's connected to each other.
Effects on other RIF's	The same as for National authorities
Comments	

F: Consequence Risk Influencing Factors

The outcome of the incident is connected to how the incident is handled. A suggestion for such an influence diagram is made. But this diagram is just set by the author.

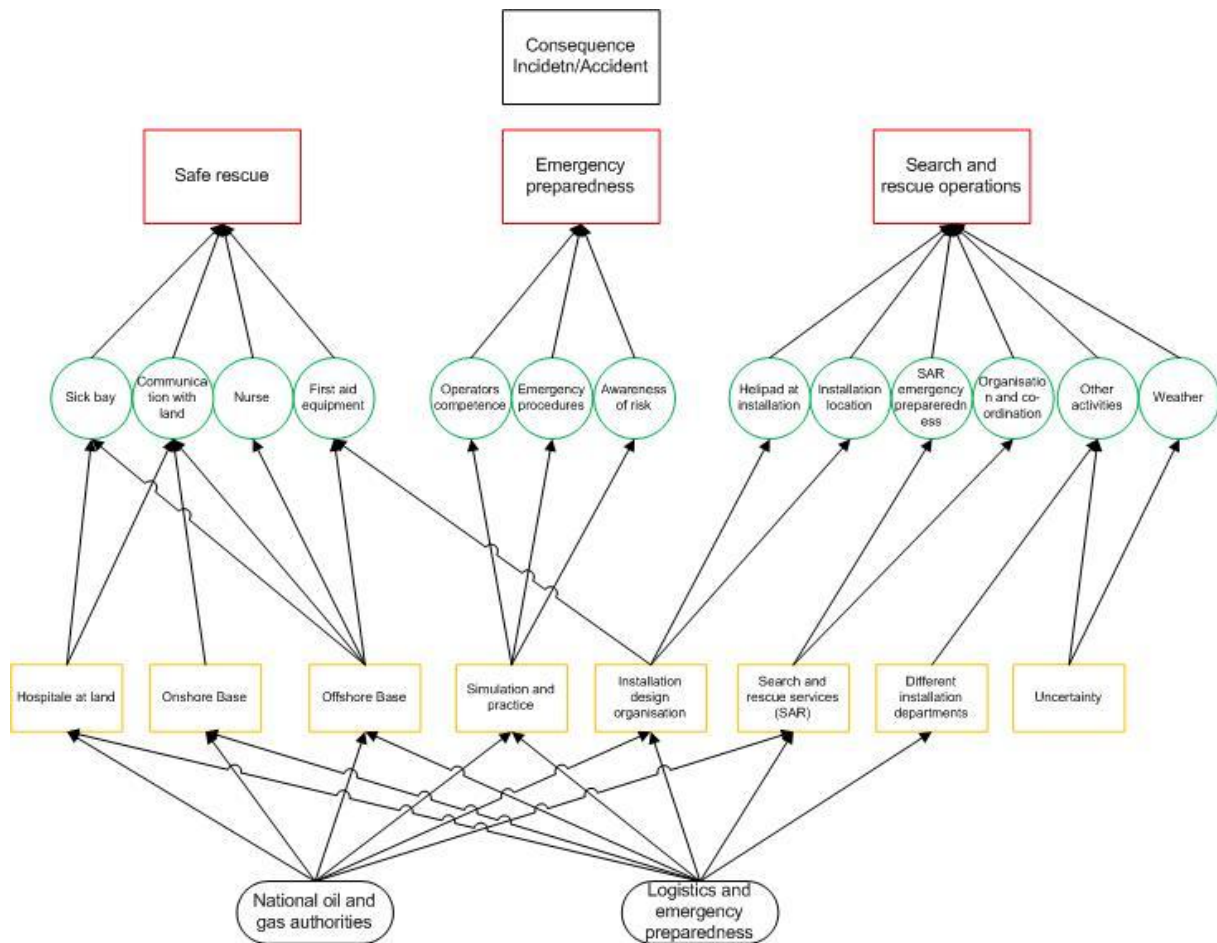


Figure 32 Influence diagram Consequence

Safe rescue

Safe rescue is very important to be able to decrease the consequences of an accident. A ward at the installation can be vital if it is no possible way to get the injured safe to land; the ward must be equipped with first aid and the most essential lifesaving equipment. In many cases there will only be a nurse offshore. If someone is badly hurt and need instantly lifesaving treatment, a nurse may have to do the job of a doctor. Then communication with a hospital onshore may be crucial. When the patient is ready to be removed to land, a prepared hospital at land is vital.

Emergency Preparedness

It is important that the operators at the installations and the supply vessels are trained in good emergency procedures, have a good awareness of risk and have the needed competence. This so that no one panics and everything is done safe and efficient.

Search and rescue operations

To get the injured safe and quick to land a helicopter operation may be needed. There are many factors that can affect a safe and good operation. A helipad at deck must be placed so that it is easy accessible and in shelter for harsh weather. The location of the installation and the location of the

SAR can be far away from each other, or far away from the coast. Some very important factors are the emergency preparedness of the SAR, its capacity, alertness and competence. The organisation and co-ordination affects the efficiency of the operation. Sometimes more than one accident happens at once and may influence each other and the weather may be a great concern regarding this kind of operations.

1. Level RIF

Sick Bay

Definition	An area where people can be given medical treatment and care.
Description	Should have equipment for small injuries and first aid.
Effects on other RIF's	Safe rescue
Comments	

Communication with Land

Definition	Communication is the systems and processes that are used to broadcast information that can influence the consequence of an accident.
Description	To give offshore the help it need under accident situation a good communication with land is important.
Effects on other RIF's	Safe rescue
Comments	

Nurse

Definition	A nurse is a person whose job is to care for people who are ill.
Description	A nurse at the installation is a must, for daily or lifesaving situations.
Effects on other RIF's	Safe rescue
Comments	

First aid equipment

Definition	The equipment used for first aid medical treatment as soon as possible to a sick or injured person.
Description	
Effects on other RIF's	Safe rescue
Comments	

Operators Competence

Definition	The operators at the installations ability to perform effectively and professional such that the consequences of an accident can be less severe.
Description	To know what to do during emergency situations is critical to reduce the consequences. Often it can be the cargo lifted by the crane that is the cause of the accident. Therefore the operators need to be trained in emergency situations as well as normal operational situations.
Effects on other RIF's	Emergency preparedness
Comments	

Emergency Procedures

Definition	Sufficient, easy accessible and understandable emergency procedures.
Description	
Effects on other RIF's	Emergency preparedness
Comments	

Awareness of risk

Definition	The operators ability to perform effectively and professional such that the consequences of an accident can be less severe.
Description	The operators are often in the critical areas during the crane operation. It is very important that they know how to handle the situation if there is an accident.
Effects on other RIF's	Emergency preparedness
Comments	

Helipad at Installation

Definition	Landing ground for helicopter
Description	Easy accessible landing ground so that the helicopter do not have any problem landing in case of an accident.
Effects on other RIF's	Search and rescue operations
Comments	

Installation location

Definition	The location of the installation
Description	Installations not far out at sea or at areas with good weather will be more easily accessible for search and rescue operations.
Effects on other RIF's	Search and rescue operations
Comments	

SAE Emergency Preparedness

Definition	The SAR service organisation, competence availability, capacity and alertness.
Description	Organisation: Sufficient plans and procedures. Number of helicopters, equipment and personnel. Competence: Personnel designated to deal with emergency situations. Availability: The SAR helicopters are located at different installations in the North Sea. It is important that in case of an accident it is easy available for other installations as well. Alertness: Immediately detecting and reacting on emergency situations.
Effects on other RIF's	Search and rescue operations
Comments	

Organisation and Coordination

Definition	The actual organisation and coordination during an SAR rescue operation.
Description	Internal and external coordination between SAR units.
Effects on other RIF's	Search and rescue operations
Comments	

Other Activities

Definition	Surroundings that affects the ability of SAR service.
Description	Other accidents Other SAR helicopters Nearby ships
Effects on other RIF's	Search and rescue operations
Comments	

Weather

Definition	The influence from weather that affect the ability of SAR service.
Description	Rough wind, rain, snow, fog waves, etc.
Effects on other RIF's	Search and rescue operations
Comments	

2. Level RIF

Hospital at land

Definition	A hospital is a place where sick and injured people are looked after by doctors and nurses.
Description	May assist the sick bay in case of first aid or if there is no possible transportation to land. Need to be prepared for incoming injured.
Effects on other RIF's	Sick bay Communication with land
Comments	

Onshore Base

Definition	Receives, handles, controls, stores and sends out cargo.
Description	Can help the installation with emergency equipment or if vessels are needed.
Effects on other RIF's	Communication with land
Comments	

Offshore Base

Definition	Controls the installations activities, from logistics to the offshore hotel service.
Description	Do what they can to prevent the situation to expand and call up the help they need.
Effects on other RIF's	Sick bay Communication with land Nurse First aid equipment
Comments	

Simulations and Practise

Definition	Simulation is a tool to learn by doing.
Description	Simulation is a great way to learn about risks and how to tackle critical situations. Simulations and practice will help the workers on the installation to handle emergency situations in a routine way. Many people panic during accidents, to practise can be a very preventive tool for panic.
Effects on other RIF's	Operators competence Emergency procedures Awareness of risk
Comments	

Installation Design Organisation

Definition	The way the design organisation plan and carry out their business in general, to the extent that this has a direct or indirect influence of the installation operational safety.
Description	The installation need to be design with regards to safety before and during accidents with sufficient equipment and first aid. The placement of the sick bay and the helipad is important factors. They also set the standard for what first aid equipment that always should be at the installation.
Effects on other RIF's	First aid equipment Helideck at installation Installation location
Comments	

Search and Rescue Services (SAR)

Definition	The way the search and rescue services plan and carry out their business in general, to the extent that this has a direct or indirect influence on the organisation and co-ordination of any given search and rescue operation. The rescue coordination centre is a important actor.
Description	
Effects on other RIF's	SAR emergency preparedness Organisation and coordination
Comments	

Different Installation Departments

Definition	
Description	If two accidents happen at once, it might expand the criticality of the situation.
Effects on other RIF's	Other activities
Comments	

Uncertainties

Definition	Suddenly incidents that require change of plan.
Description	Can be weather or other accidents.
Effects on other RIF's	Other activities Weather
Comments	

3. Level RIF

National Oil and Gas Authorities.

Definition	The effect the national authorities have on: Safety regulations and design standards Requirements on crane design and manufacture, O&M Simulations and practice Certification and licensing of personnel Working conditions Responsibility of cargo Metrology and Communication Service
Description	
Effects on other RIF's	Hospital at land Onshore base Offshore base Crane simulations and practice Installation design organisation Search and rescue services
Comments	The international and national rules are much the same. In Norway the rules and requirements for safe operations are very strict; therefore I have not taken the international rules as a RIF.

Logistics and Emergency Preparedness

Definition	Department of Statoil that controls large accidents which is connected to the oil and gas industry.
Description	If a severe accident happens, they do everything in their power to decrease the damage and do the recovery operation as efficient as possible.
Effects on other RIF's	Hospital at land Onshore base Offshore base Crane simulations and practice Installation design organisation Search and rescue services Different installation departments
Comments	

G: Analysis

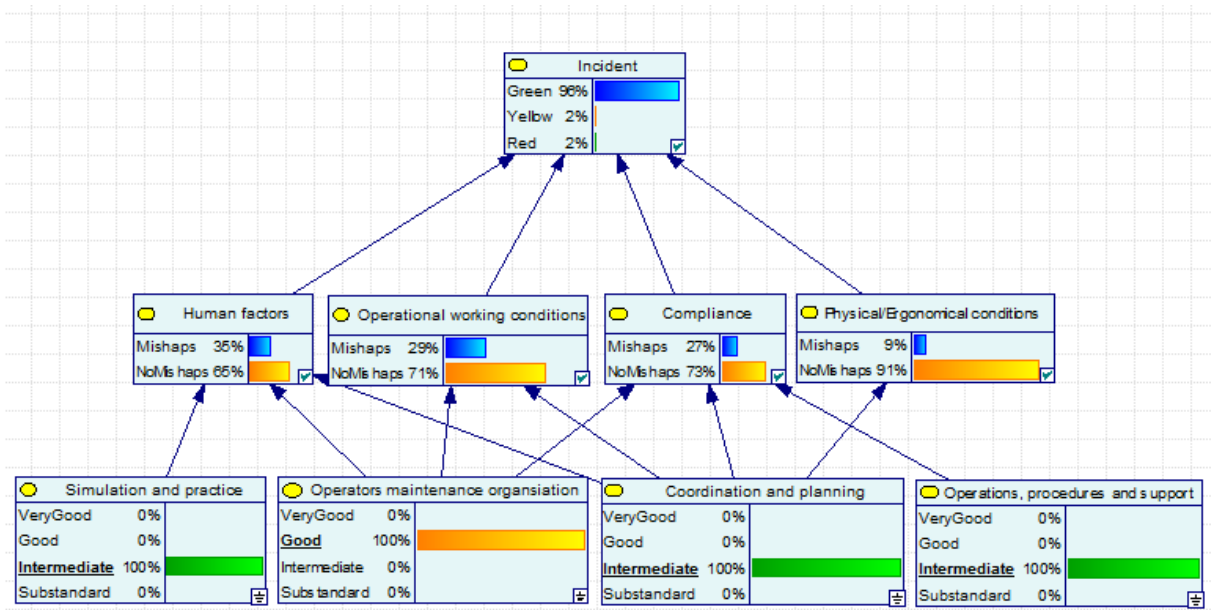


Figure 33 Today's situation

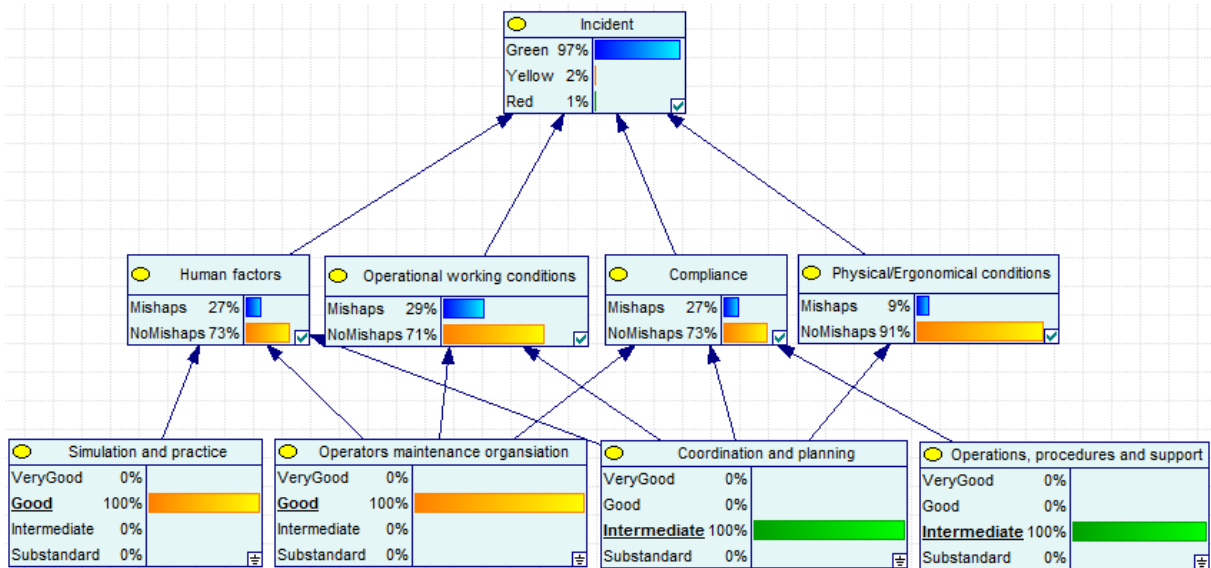


Figure 34 One level change in Simulation and Practice

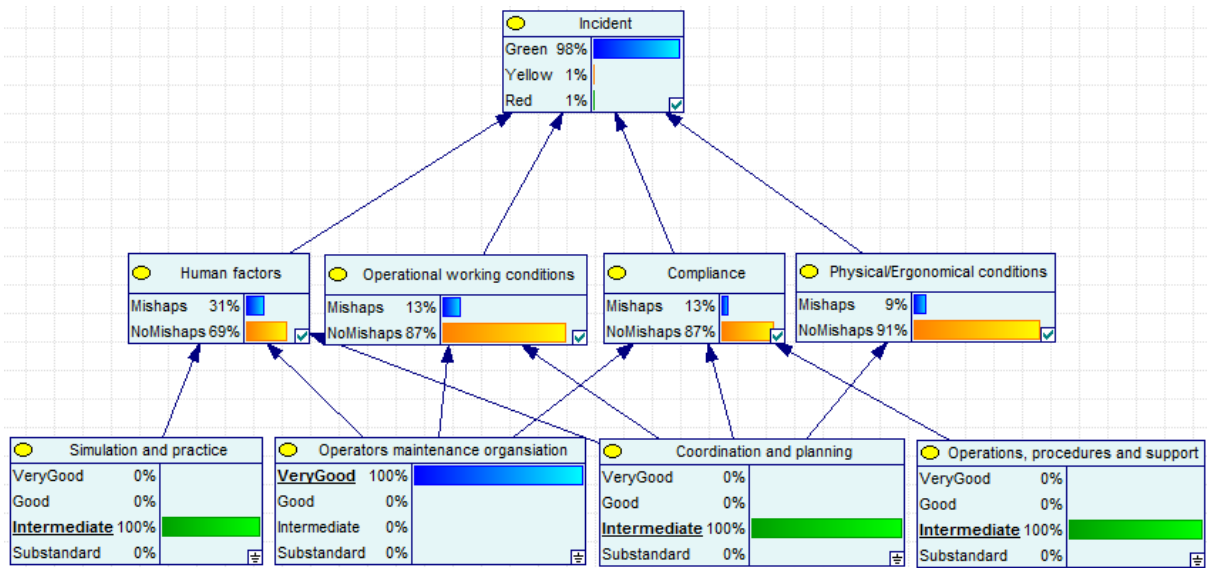


Figure 35 One level change in Operators, Maintenance Organisation

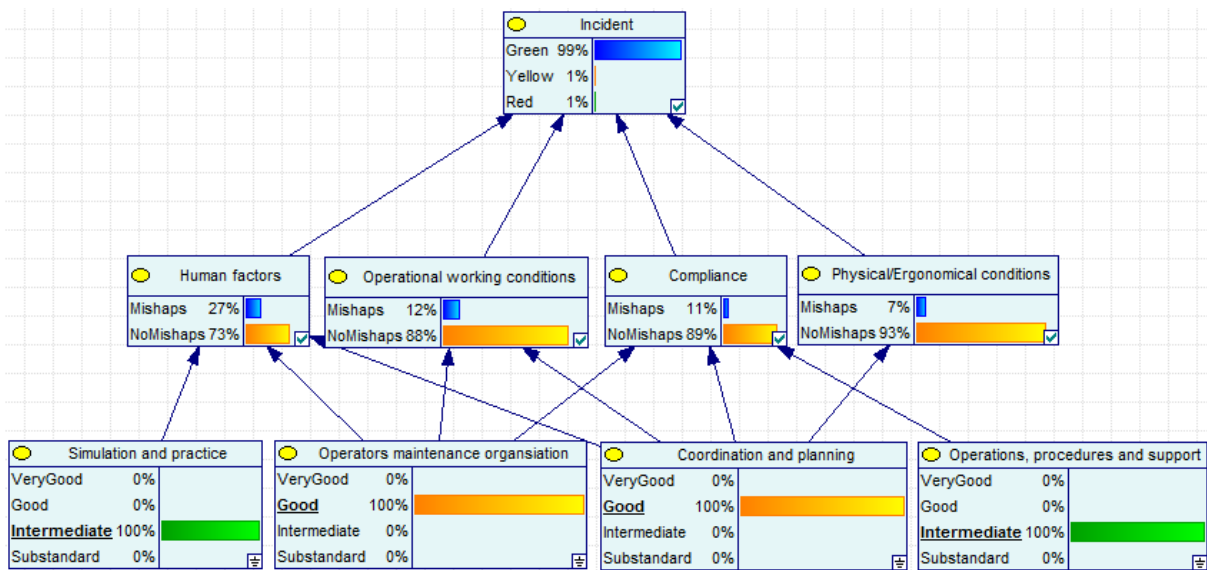


Figure 36 One level change in Cooperation and planning

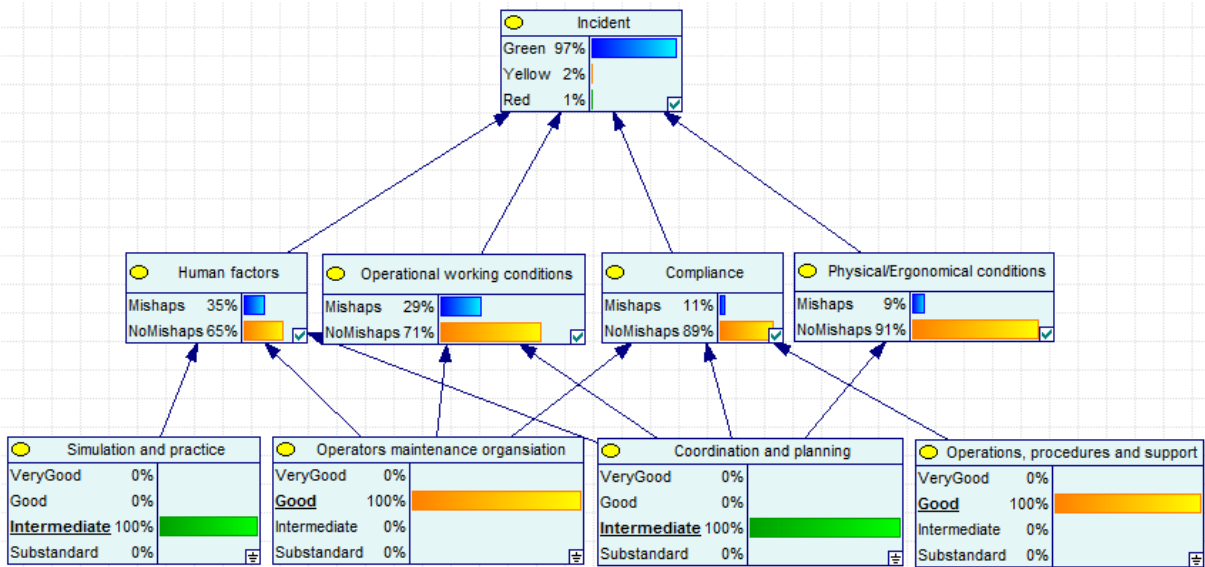


Figure 37 One level change in Operations, Procedures and Support

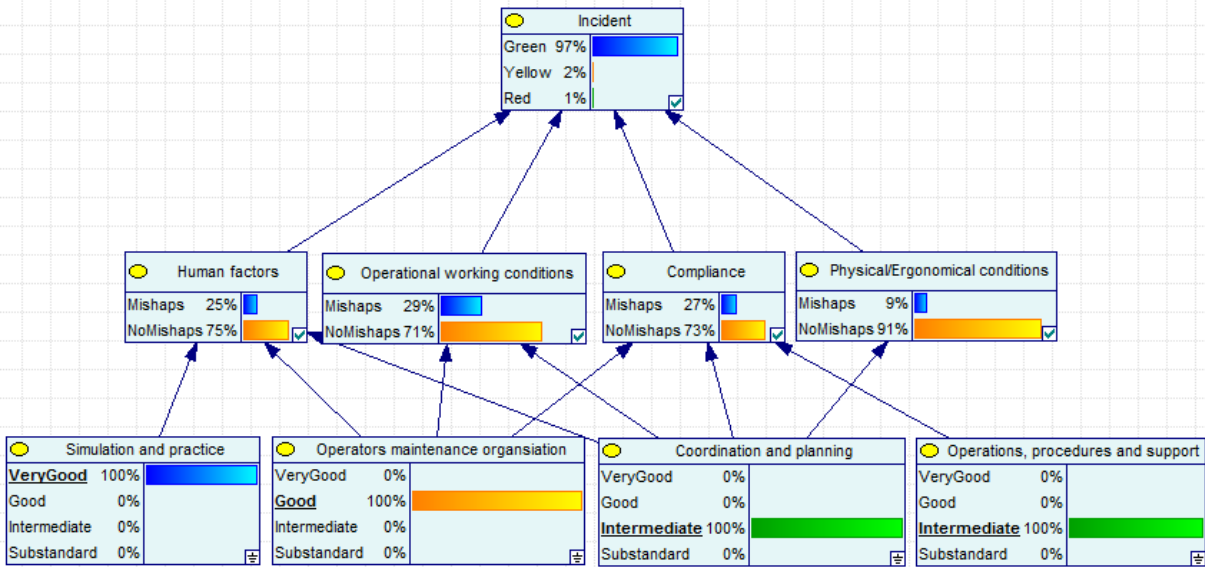


Figure 38 Two level change in Simulation and Practice

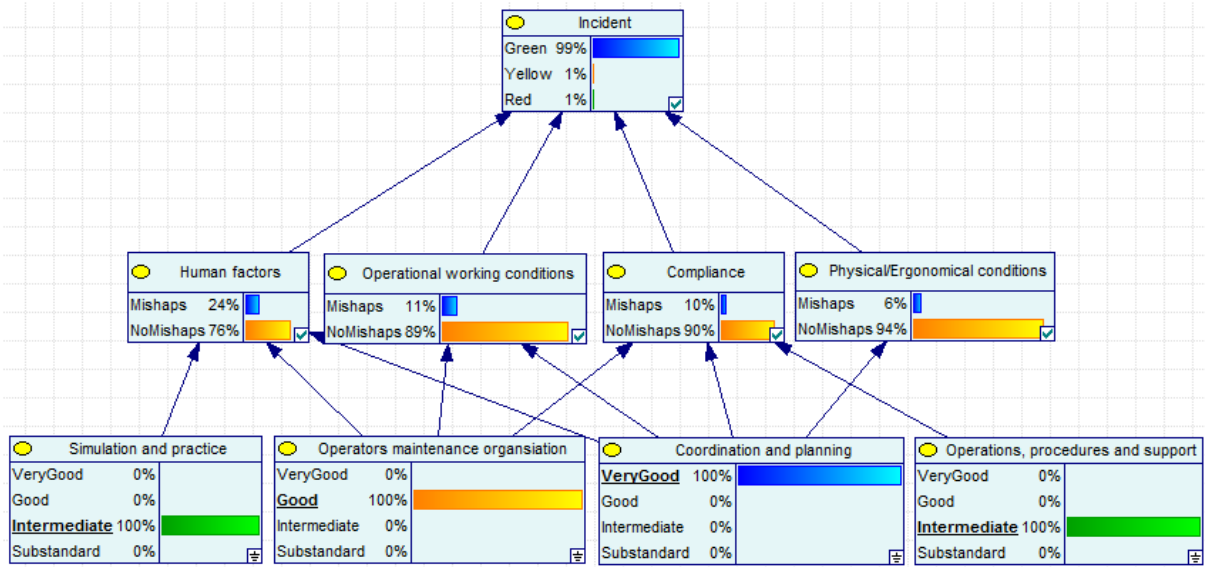


Figure 39 Two level change in Coordination and Planning

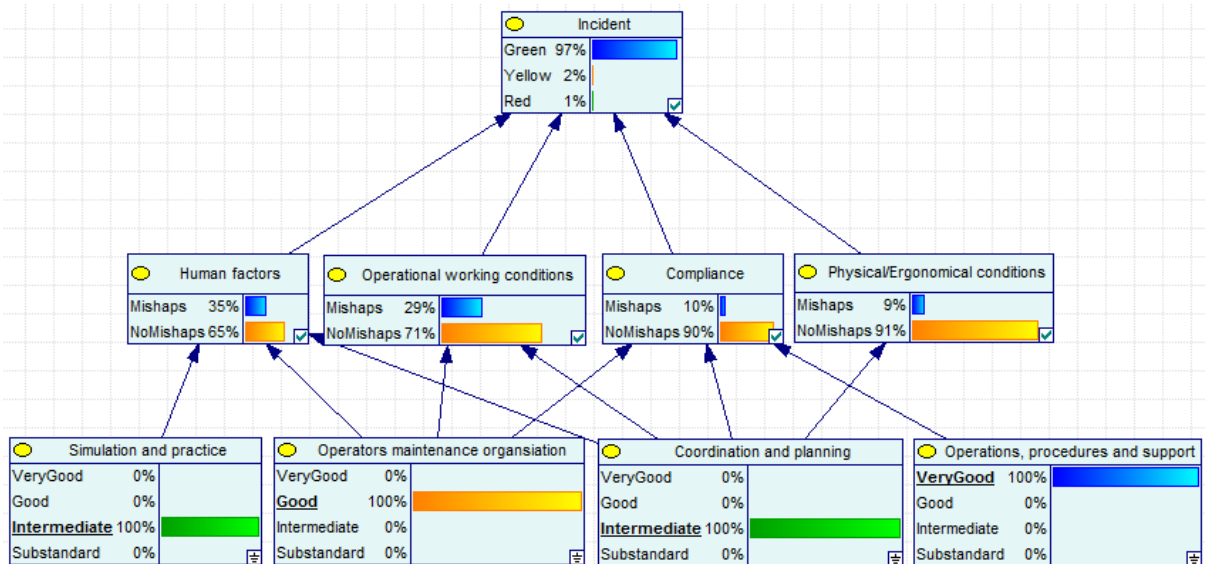


Figure 40 Two level change in Operations, Procedures and Support

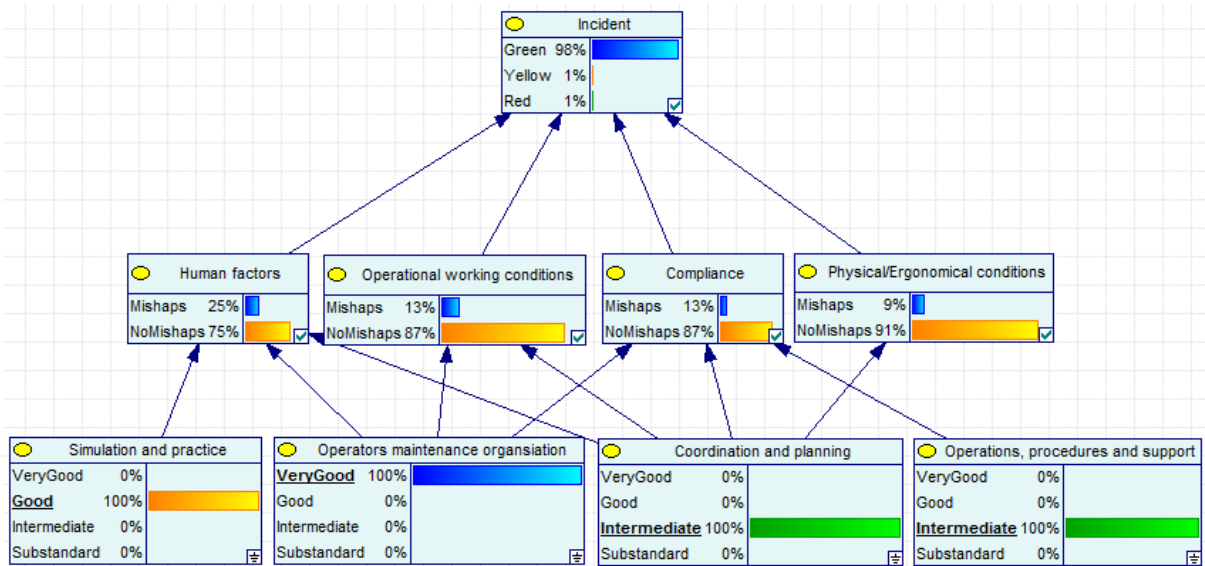


Figure 41 One level change in Simulation and Practice and Operators Maintenance Organisation

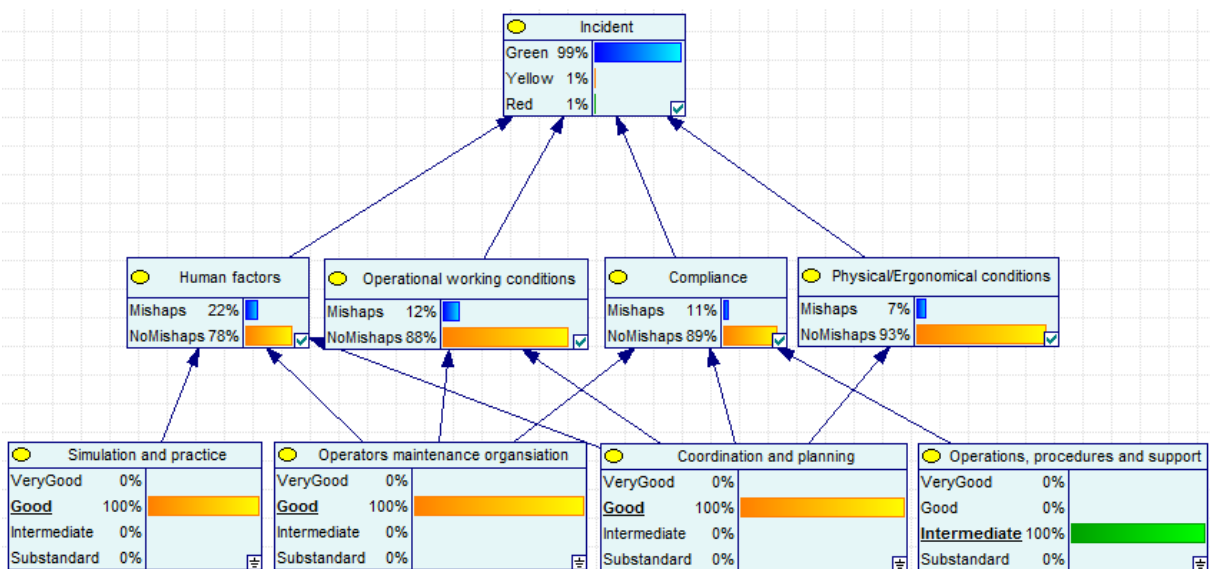


Figure 42 One level change in Simulation and Practice and Coordination and Planning

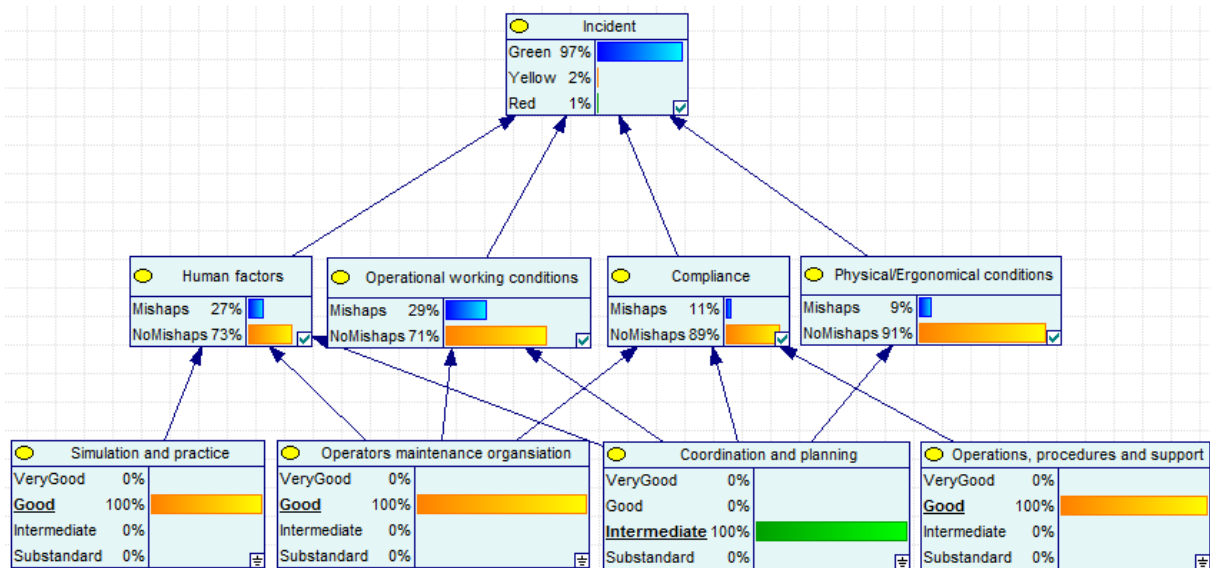


Figure 43 One level change in Simulation and Practice and Operations, Procedures and Support

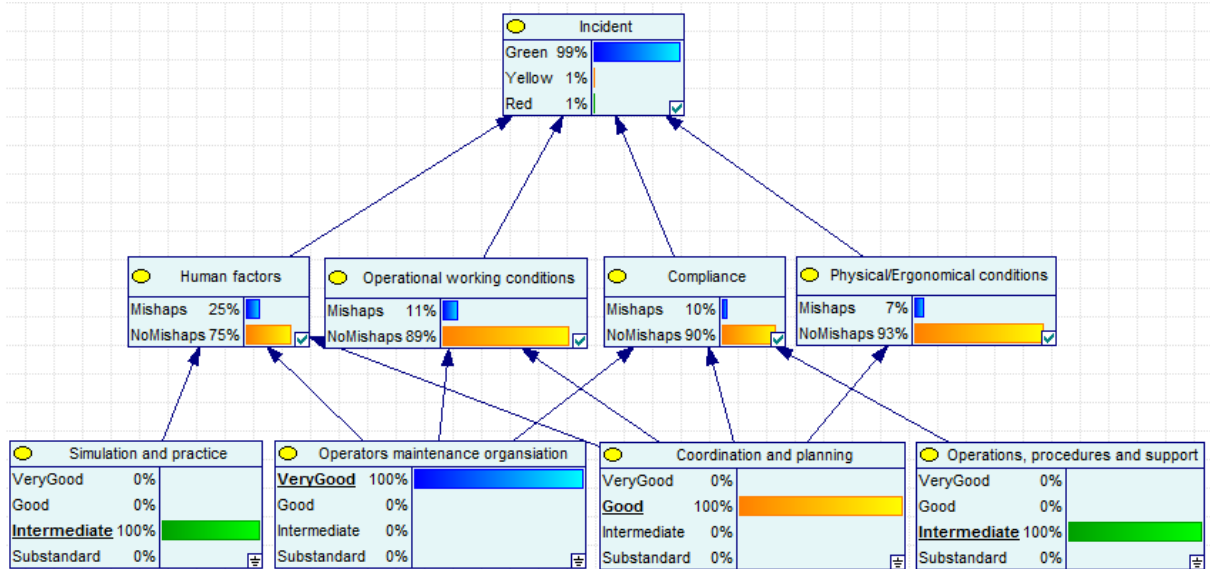


Figure 44 One level change in Operators Maintenance Organisation and Coordination and Planning

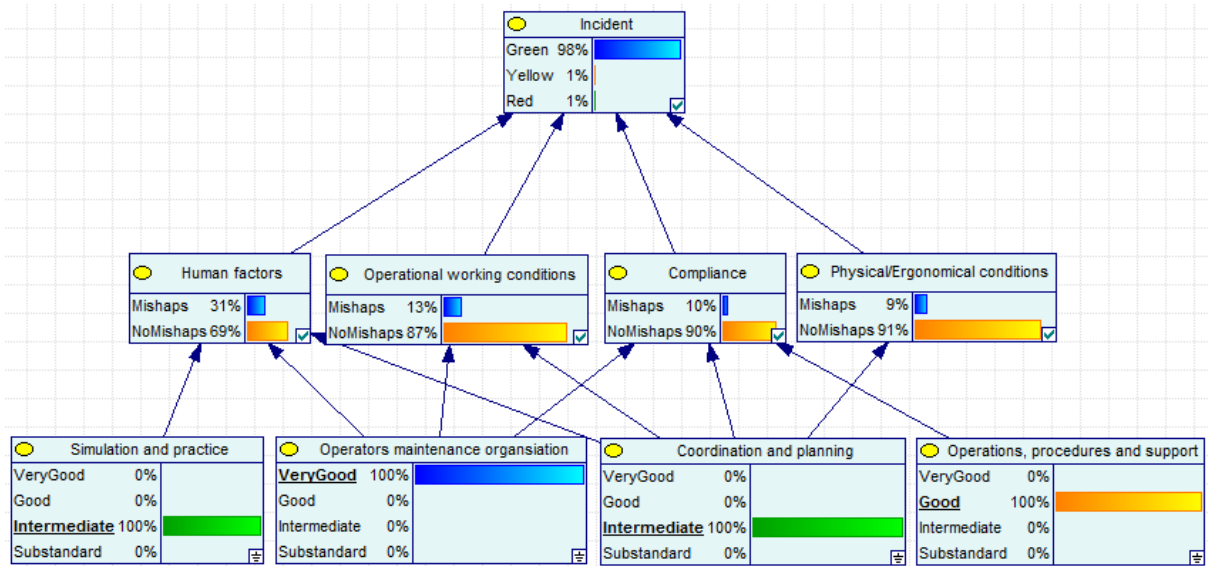


Figure 45 One level change in Operators Maintenance Organisation and Operations Procedures and Support

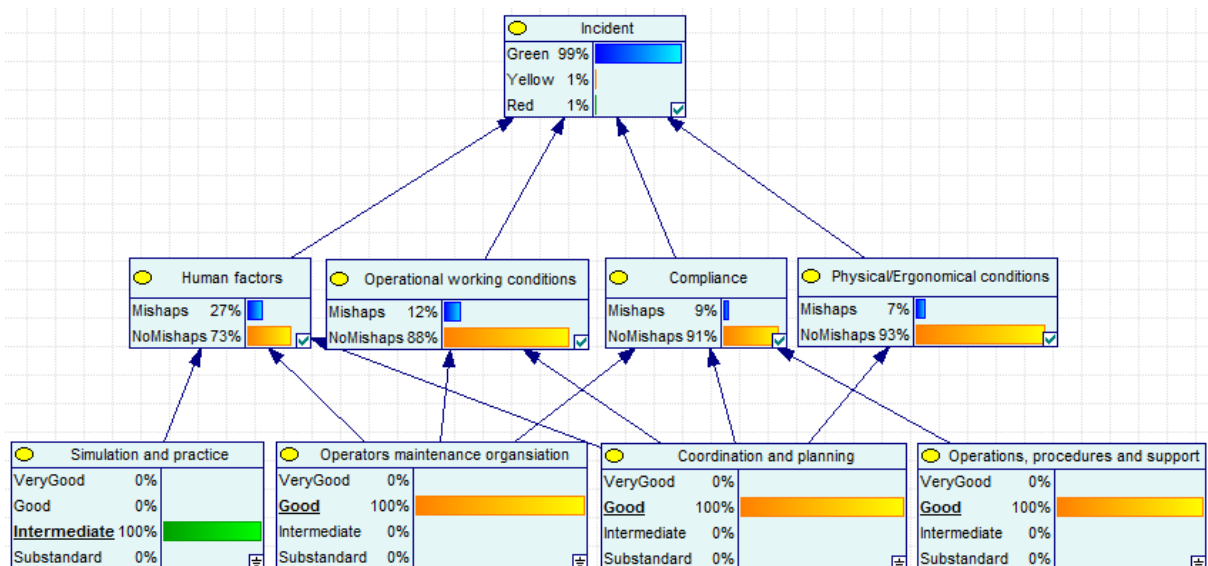


Figure 46 One level change in Coordination and Planning and Operations, Procedures and Support

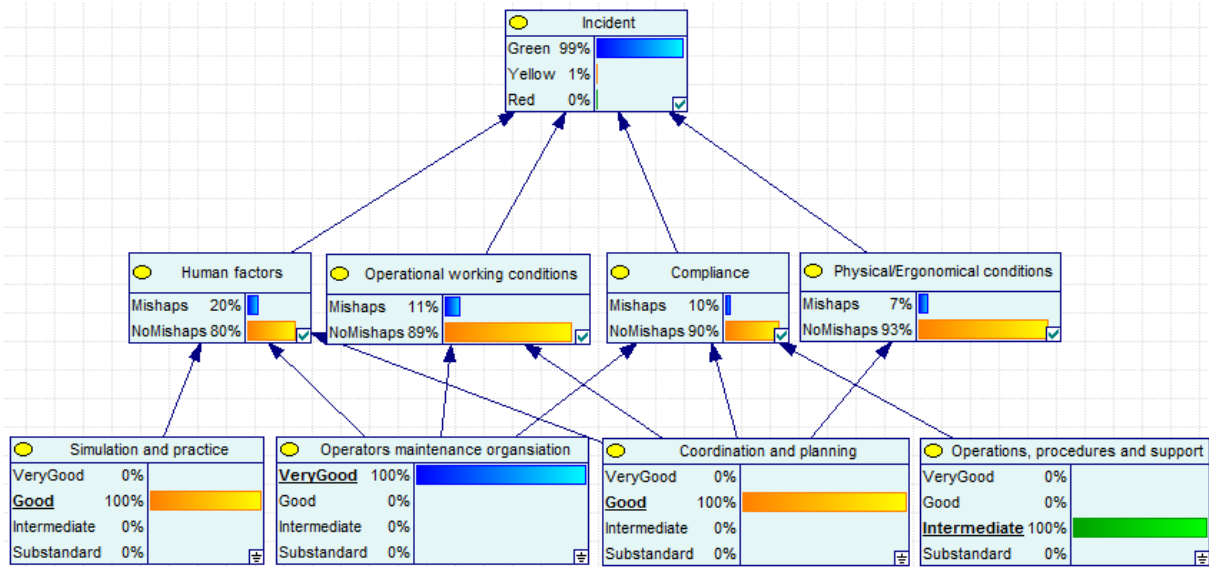


Figure 47 One level change in Simulation and Practice, Operators Maintenance Organisation and Coordination and Planning

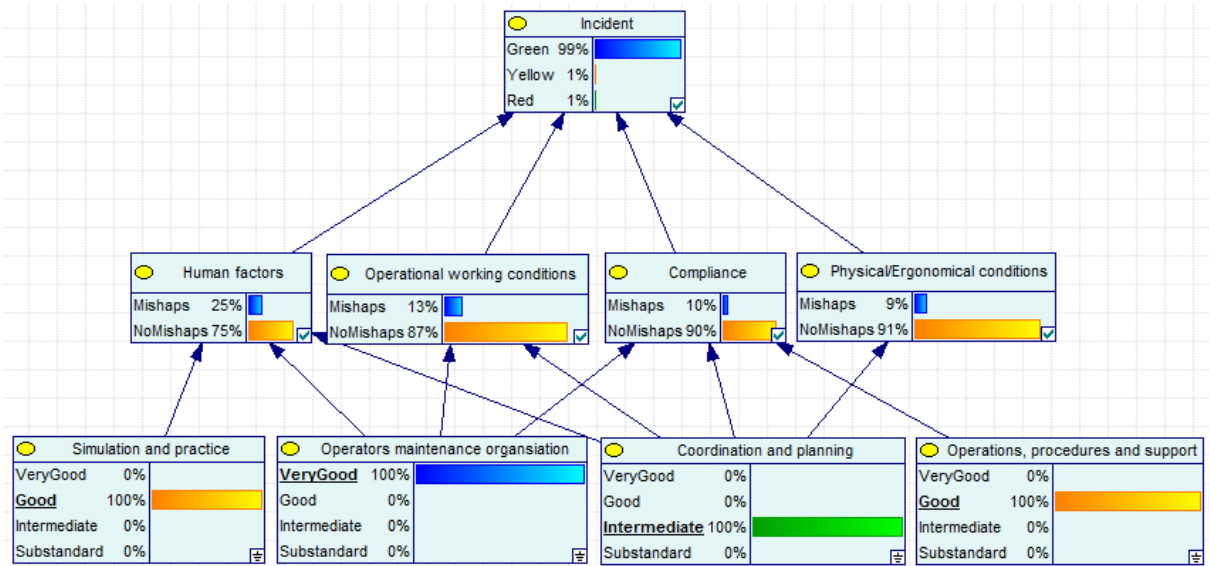


Figure 48 One level change in Simulation and Practice, Operators Maintenance Organisation and Operations, Procedures and Support

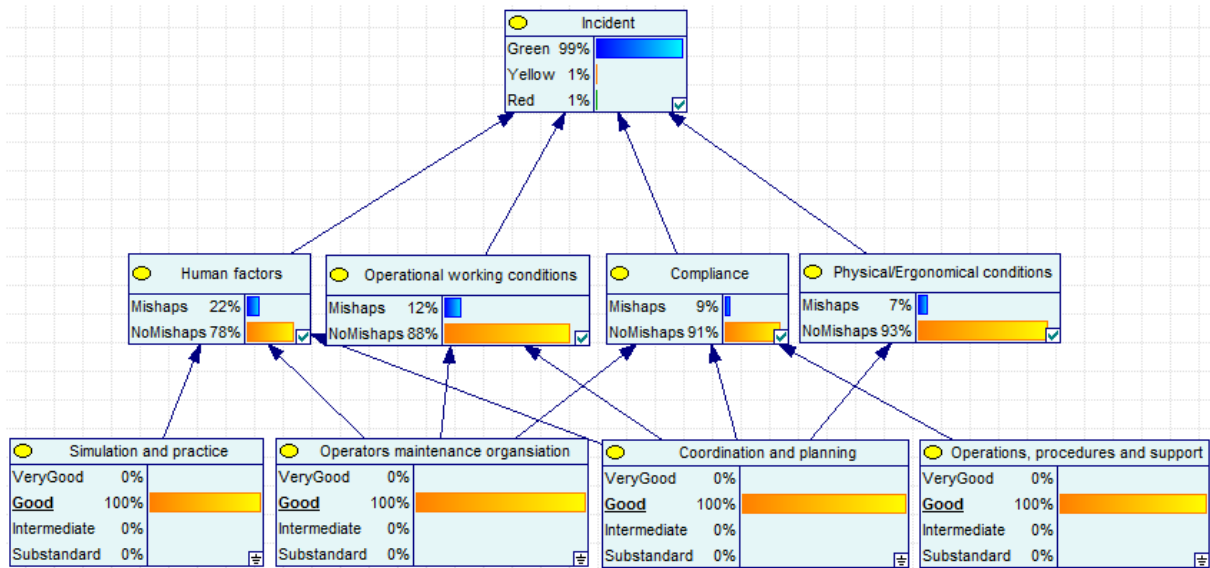


Figure 49 One level change in Simulation and Practice, Coordination and Planning and Operations, Procedures and Support

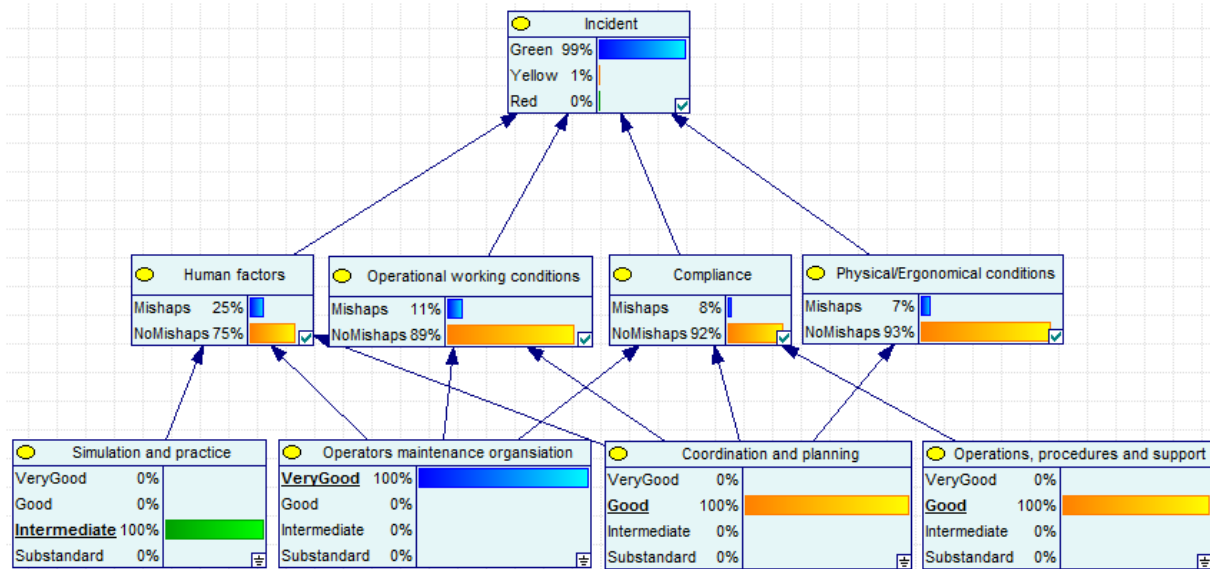


Figure 50 One level change in Operators Maintenance Organisation, Coordination and Planning and Operations, Procedures and Support

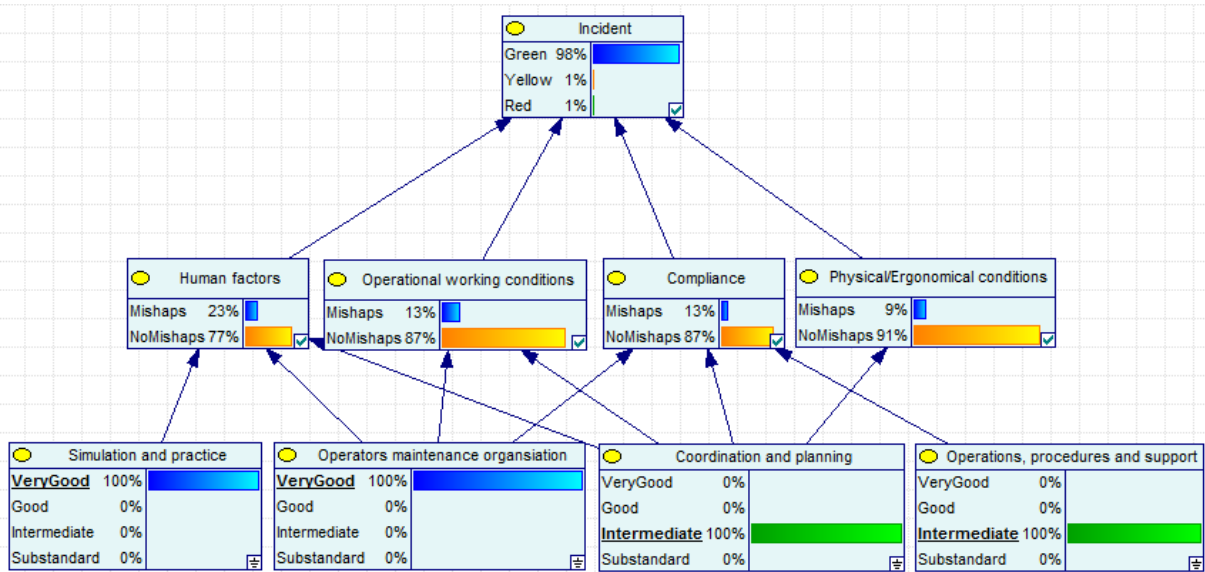


Figure 51 Two level change in Simulation and Practice and one level change in Operators Maintenance Organisation

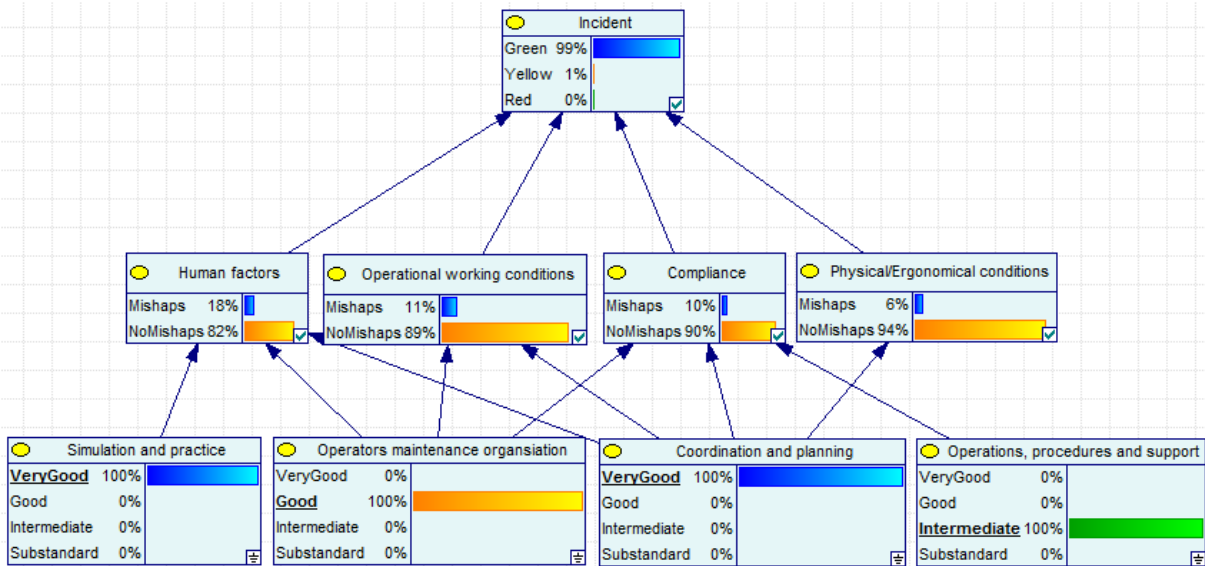


Figure 52 Two level change in Simulation and Practice and Coordination and Planning

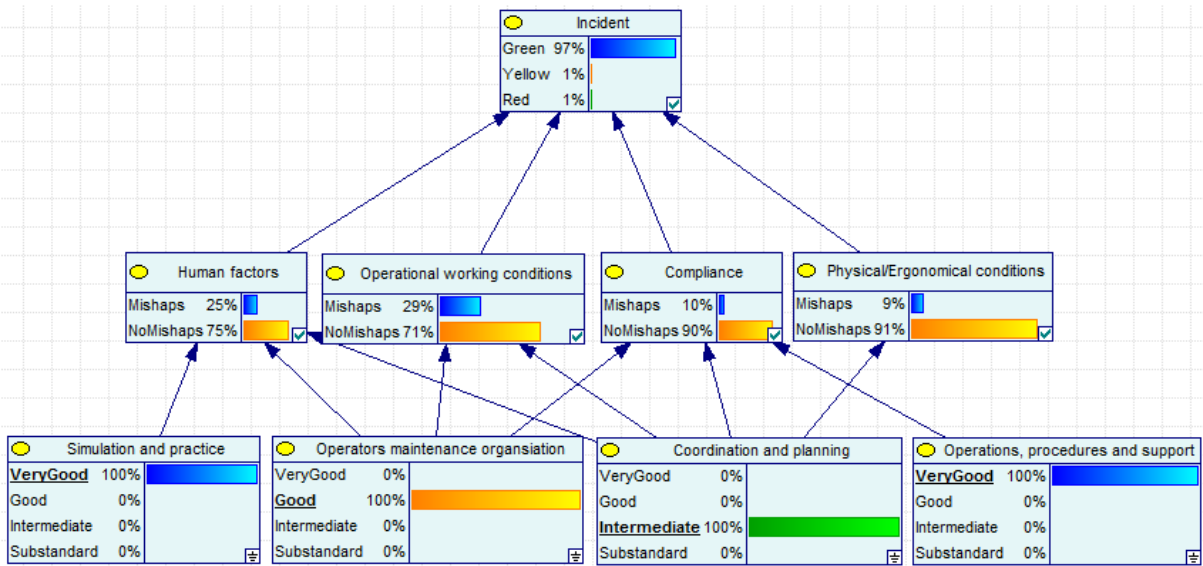


Figure 53 Two level change in Simulation and Practice and Operations, Procedures and Support

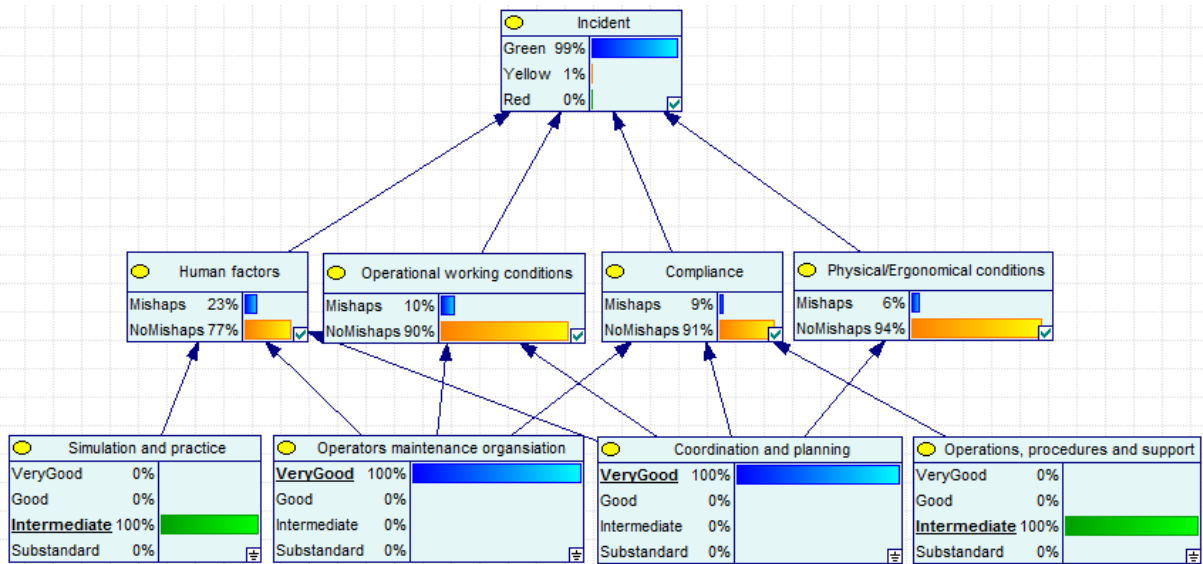


Figure 54 One level change in Operators Maintenance Organisation, two level change in Coordination and Practice

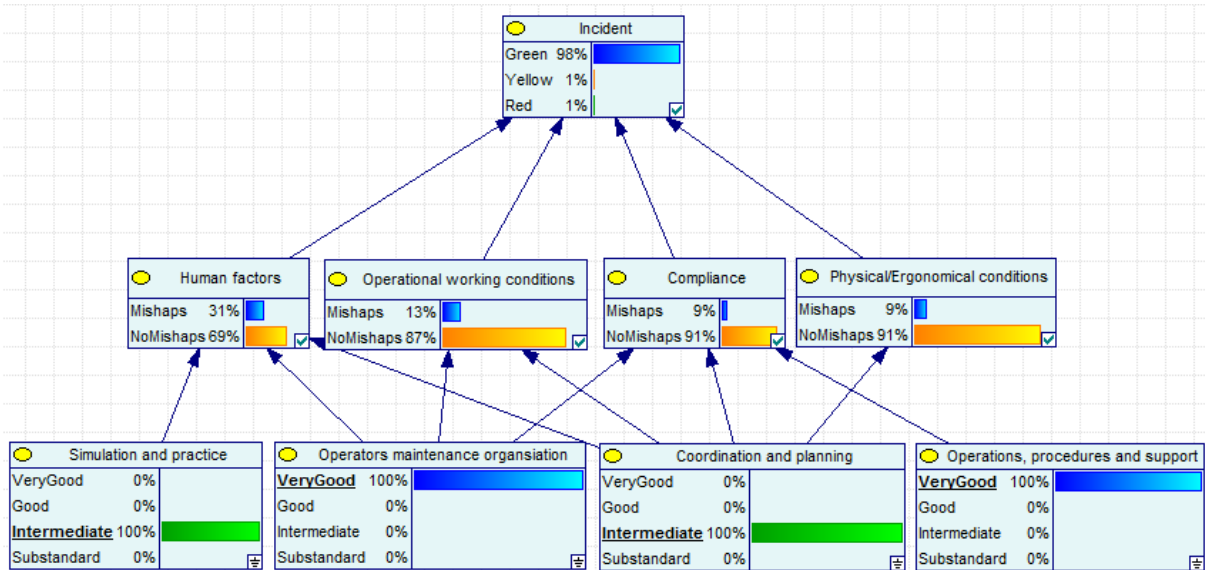


Figure 55 One level change in Operators Maintenance Organisation and two level change in Operations, Procedures and Support

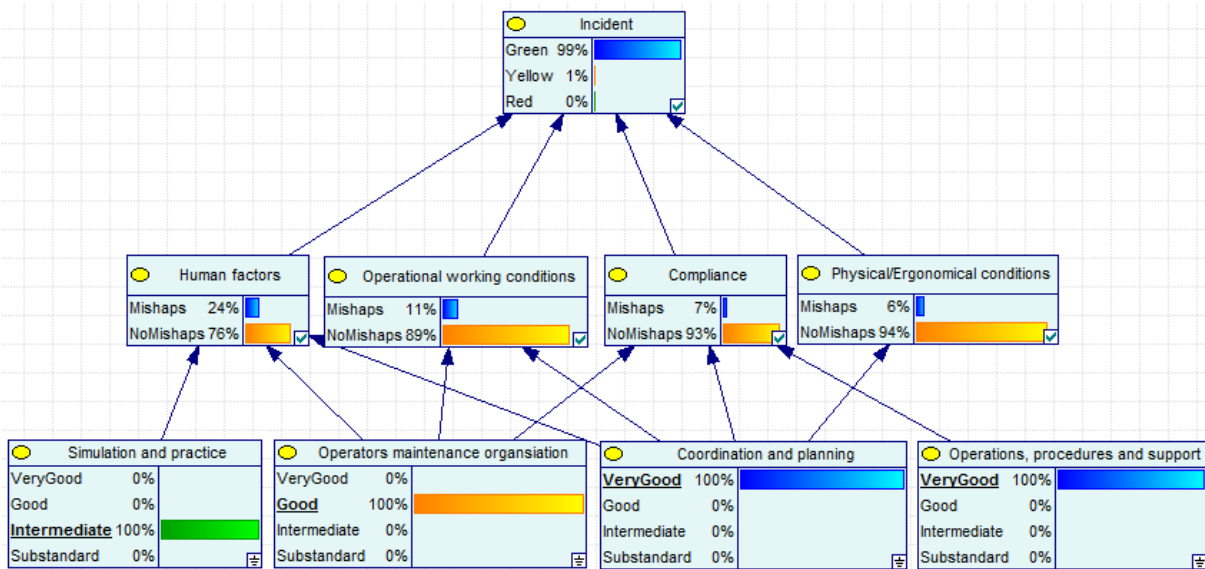


Figure 56 Two level change in Coordination and Planning and Operations, Procedures and Support

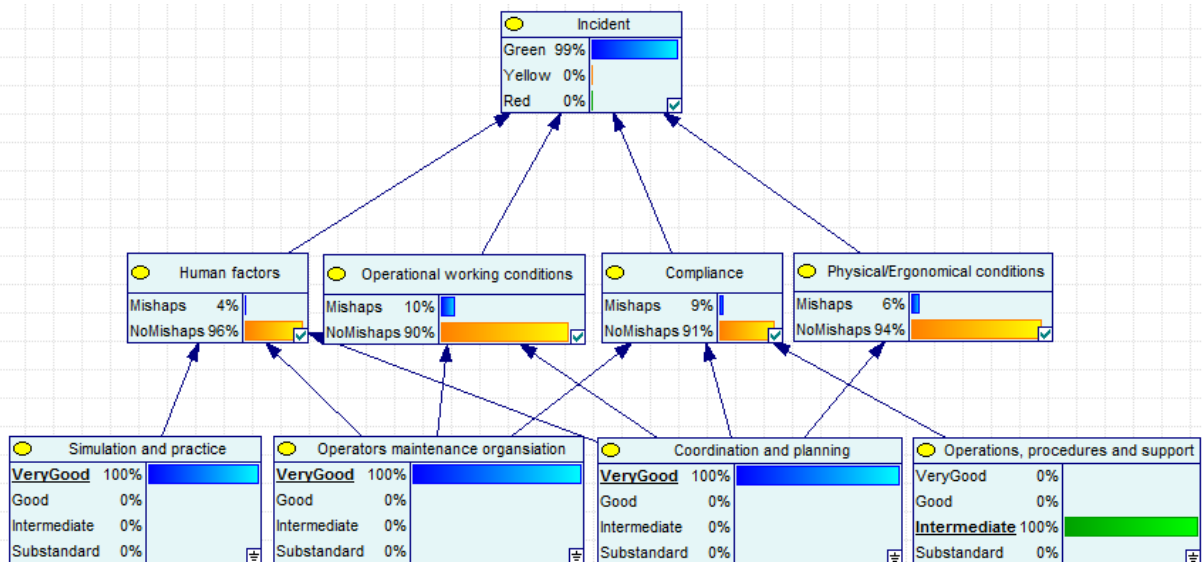


Figure 57 Two level change in Simulation and Practice and Coordination and Planning and one level change in Operators Maintenance Organisation

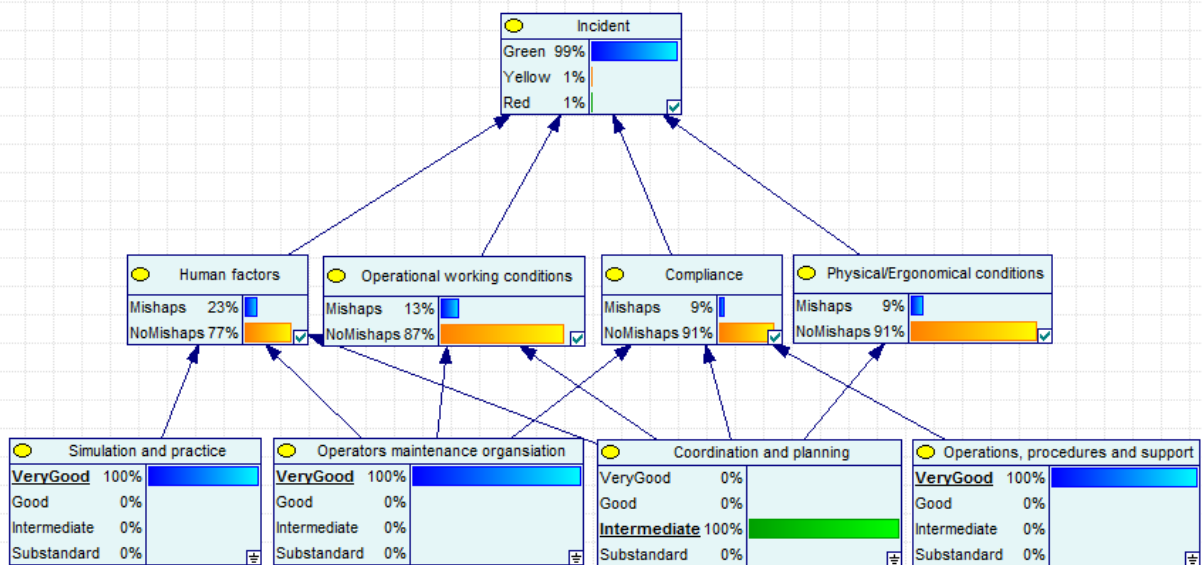


Figure 58 Two level change in Simulation and Practice and Operations, Procedures and Support, one level change in Operators Maintenance Organisation

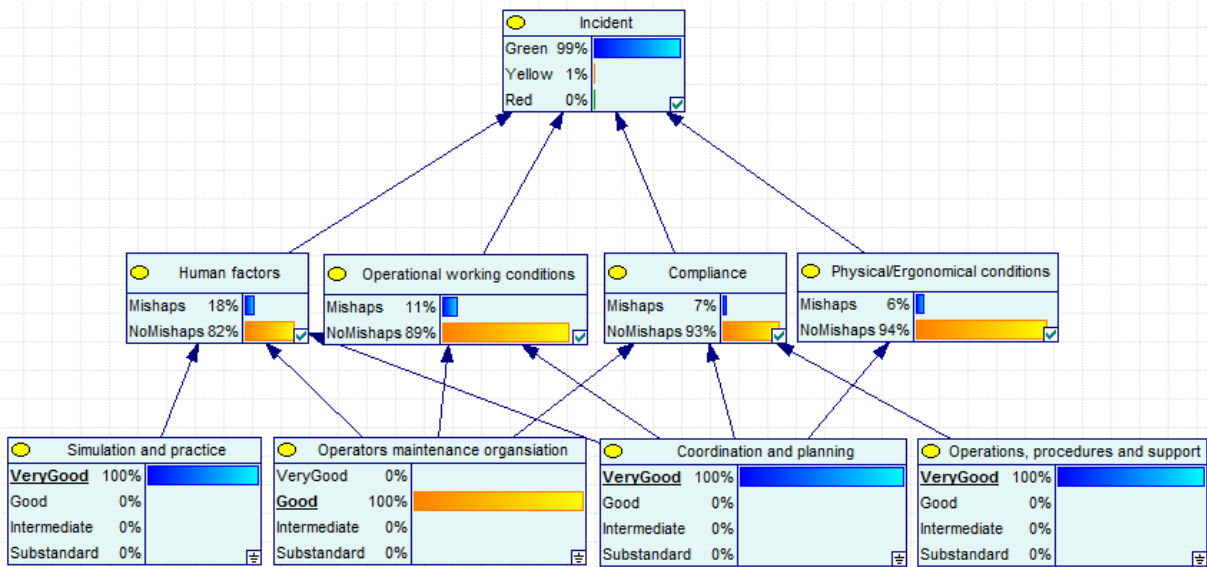


Figure 59 Two level change in Simulation and Practice, Coordination and Planning and Operations, Procedures and Support

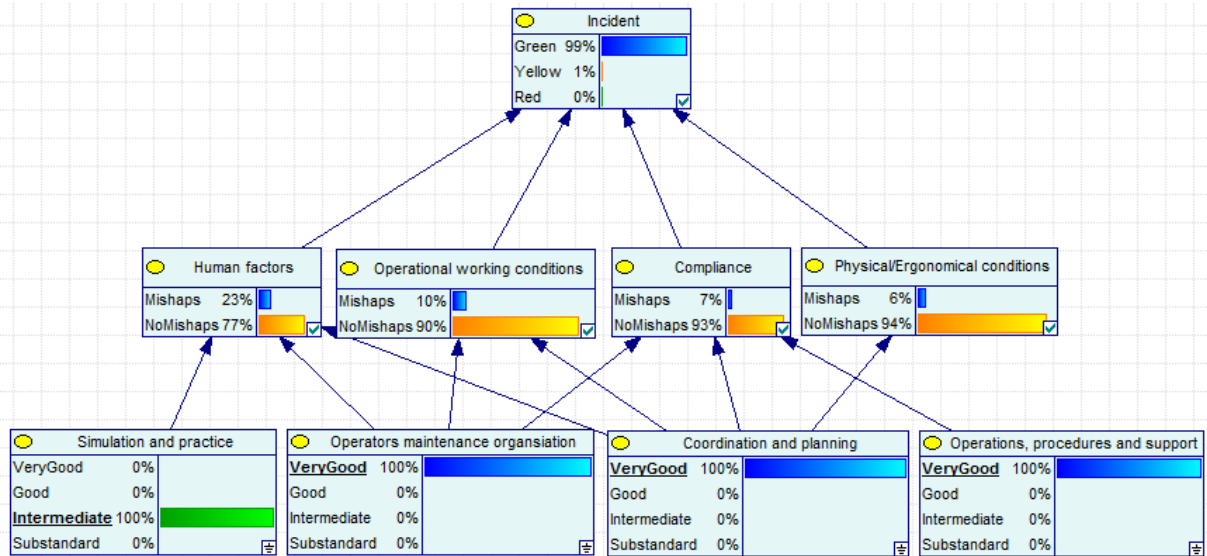


Figure 60 One level change in Operators Maintenance Organisation, two level change in Coordination and Planning and Operations, Procedures and Support

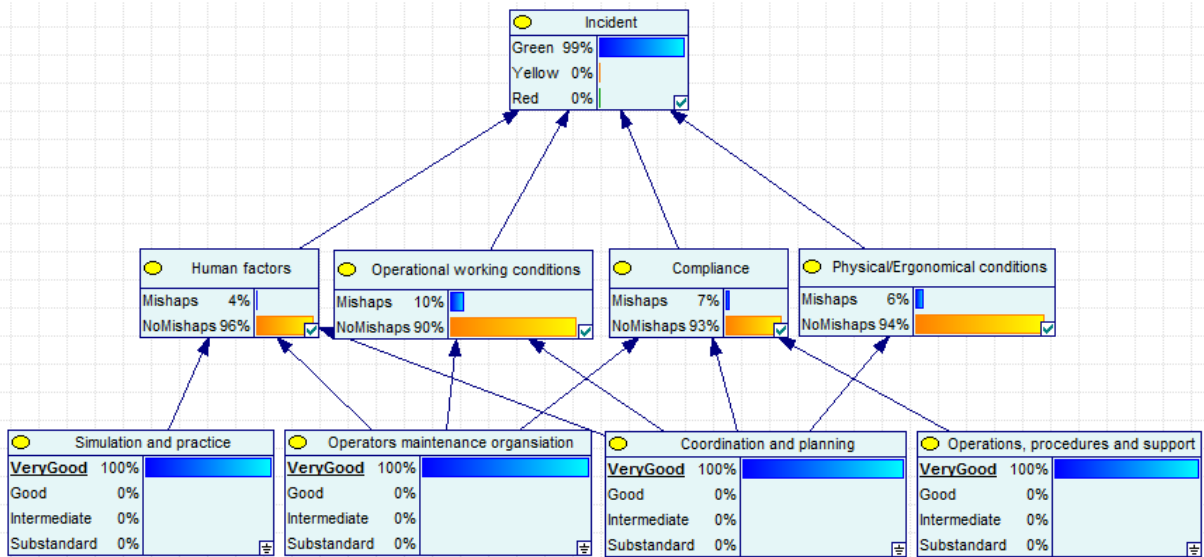


Figure 61 All changed to Very Good

H: Risk Matrix

Matrise for kategorisering og klassifisering av uønskede HMS-hendelser i U&P Norge – v.12

VARSLING med påfølgende rapportering til myndighetene (*)		SOKKEL: MELDING til Pål første arbeidsdag. (*) LAND: Olje- og gasslekkasjer varsles, personskader rapporteres.		RAPPORTERING til myndighetene		Selskapsintern rapportering og registrering i Synergi (alle uønskede hendelser)																			
Nr	Personskade		Arbeidsrelatert sykdom (ARS)		Oljeutslipp Uhellstutslipp		Kjemikalieutslipp Hav		Kjemikalieutslipp Land		Olje- / gasslekkasje		Brann/ eksplosjon		Sveikning/bortfall av sikkerhetsfunksjoner og barrierer (som)		Omdømme		Tap av produksjon		Materiell skade og andre økonomiske tap				
	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig			
Aberlighetsgrad	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
		Dødsfall		Arbeidsrelatert sykdom som medfører død		Sokkel: > 1000m ³ Land: > 100m ³		Svart>10m ³ Rød>1000m ³ Gul>10000m ³		Grupper1>1m ³ Gruppe2>100m ³		> 10 kg/s eller kortvarig > 100kg		Store deler av innretningen eller anlegget eksponert		Truer hele innretningen eller anlegget		Stor internasjonal negativ eksponering i media og mellom organisasjoner		Nedetid > 10 dager		Skader av større omfang. Sokkel > 50 mill. NOK Land > 25 mill. NOK		<input type="checkbox"/>	
		①	②	①	②	①	②	①	②	①	②	①	②	①	②	①	②	①	②	①	②	①	②	①	②
	2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Alvorlig fraværskade/ alvorlig personskade		Alvorlig arbeidsrelatert sykdom		Sokkel: > 100m ³ Land: > 10m ³		Svart>1m ³ Rød>100m ³ Gul>1000m ³		Grupper1>500liter Gruppe2>10m ³		1-10 kg/s eller kortvarig > 10kg		Deler av innretningen eller anlegget eksponert (f. eks en modul)		Truer store deler av innretningen eller anlegget (f.eks. flere moduler)		Middels internasjonal negativ eksponering i media og mellom organisasjoner		Nedetid > 5 dager		Sokkel > 25 mill. NOK Land > 15 mill. NOK		<input type="checkbox"/>	
	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	②	
3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Øvrig fraværskade eller personskade med alternativt arbeid *		Arbeidsrelatert sykdom som medfører kortvarig fravær eller begrenset alternativt arbeid		Sokkel: > 1m ³ Land: > 1m ³		Svart>100liter Rød>10m ³ Gul>100m ³		Grupper1>100liter Gruppe2>1m ³		0,1-1 kg/s eller kortvarig > 1 kg		Lokalt område eksponert (f.eks. del av modul)		Truer deler av innretningen eller anlegget (f.eks. en modul)		Nasjonal negativ eksponering i media, fra myndigheter på nasjonalt nivå		Nedetid > 3 dager		> 10 mill. NOK		<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Medisinsk behandlingsskade		Arbeidsrelatert sykdom som medfører behandling fra autorisert helsepersonell		Sokkel: > 100liter Land: > 100liter		Svart>100liter Rød>1m ³ Gul>10m ³		Grupper1>10liter Gruppe2>250liter		< 0,1 kg/s		Liten fare for innretning eller anlegg		Truer lokalt område (f.eks. del av en modul)		Lokal/regional negativ eksponering i media, fra myndigheter og kunder		Nedetid > 1dag		> 500 000 NOK		<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Førstehjelpsskade **		Øvrig arbeidsrelatert sykdom		Sokkel: 10-100liter Sokkel: < 10liter Land: < 100liter		Rød: 0,01-1m ³ Gul: 0,1-10m ³ Grønn: >10 m ³		Grupper1<10liter Gruppe2<250liter		<< 0,1 kg/s (Vesentlig mindre enn 0,1 kg/s)		Neglisjert fare for innretning eller anlegg		Neglisjert fare for innretning eller anlegg		Begrenset til få personer eller en kunde		Nedetid < 1 dag		< 500 000 NOK		<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

* OBS! Fargekodene som indikerer varslings, melding og rapportering til myndighetene er veiledende. For å oppfylle myndighetenes krav se detaljer under "Varsle?" i HMS01.01.
 ** Varsling til Pål skal gå via vaksentellen Forus, på telefon 102/14-190002 (off) eller 51990002 (ekst).
 *** Førstehjelpsskader (dykking/trykammer (dvs. personer under for høy tryk atmosfærisk omgivelsestrykk), er rapporteringspliktige på NAV skema til Pål og NAV.
 Alle utslipp skal registreres i Synergi. Fargekodene gjelder varslings og melding til myndighetene. MERK: (X) kan sette nærmerebestemte krav til varslings og melding i særlige tilfeller f.eks. i spesielt sårbare områder.

① Gransking ved KLFO
 ② Gransking ved RORE

Figure 62 Risk Matrix Statoil

(Økland, Information received during Statoil meetings, 2010/2011)

I: Pictures during observations



Figure 63 Container loaded by supplier/subcontractor



Figure 64 Lifting operation

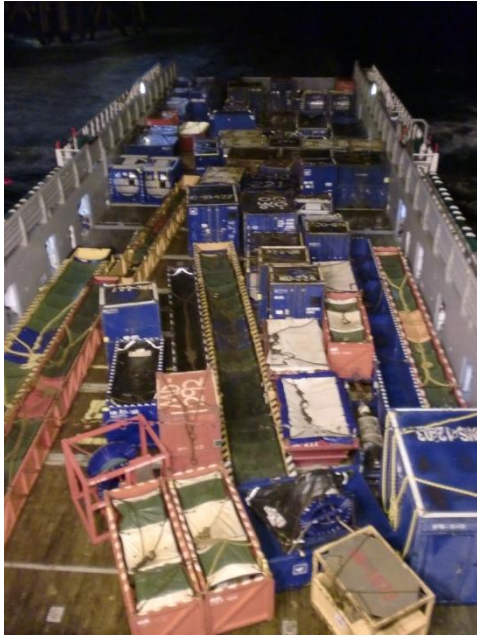


Figure 65 Fully loaded supply vessel deck



Figure 66 Placement of containers on installation