A Subsea Operation in Action

A Brief Overview of How IMR Subsea Operations are Organized and Executed

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Foreword

The subsea infrastructure that services oil and natural gas wells off the coast of Norway requires inspection, maintenance, and repair (IMR). Some of this work takes place on the surface on the oil and gas installations. We have studied subsea IMR operations are performed from purpose-built vessels. The present report commits to paper presentations that have been given to students and scholars to introduce them to the organizational challenges[1] of IMR operations. In our research, IMR vessels were picked as an example (of several) to study how organizations in petromaritime operations are handling complexity. We looked for examples with significant complexity challenges, and a good track record for safe, efficient, and effective operations. By looking closely at the execution of successful operations we hoped to discover mechanisms (formal and informal) that could explain their resilience (Johannessen, McArthur and Jonassen 2015). Those familiar with studies of high reliability organizations (HROs) will recognize the research logic implied in our approach (Weick and Sutcliffe 2007).

The information was collected over three years starting in 2009 and involved several researchers. In the spring of 2009 our team conducted background interviews. In April-May 2009, Jan R. Jonassen went on a two-week field trip to observe an IMR vessel in action, and to perform interviews on site. The purpose was to familiarize the research team with IMR operations and to develop sharper research questions. In 2010 new interviews were conducted by Nils Sortland and Idar Alfred Johannessen that focused on organizational learning. In 2011 Jonassen and Johannessen collected new data on IMR vessels during port calls, to broaden our understanding with several configurations of companies, vessels and shifts. Background information on the regulatory regime was collated by Per-Willy Hetland, Paul Glenn, and Terje Iversen. Associate professor Jens-Christian Lindaas gave valuable advice on earlier versions of the present document.

This research originated as part of the project MCPMO (Managing Complexity in Petromaritime Operations) funded by The Research Council of Norway (80%) and regional companies (20%) (Deep Ocean, Østensjø Rederi, Statoil TNE, Solstad Offshore, Eidesvik Offshore, Knutsen OAS, Gassco). It has been expanded and completed within the framework

1 Documentation that gives an overview of this business has been hard to find in one place with the exception of Jens-Christian Lindaas' introduction to the technical side (Lindaas 2013).

of RISKOP. We take this opportunity to thank our business partners and the officers and crew members of the IMR vessels for giving us access to their busy, daily lives, and for taking the time to read our drafts and give us feedback. In what follows, we base our account in large measure on the field trip with the Edda Fauna, and take that vessel as our exemplar case. We do, however, add information from other vessels and crews to create a more complete story.

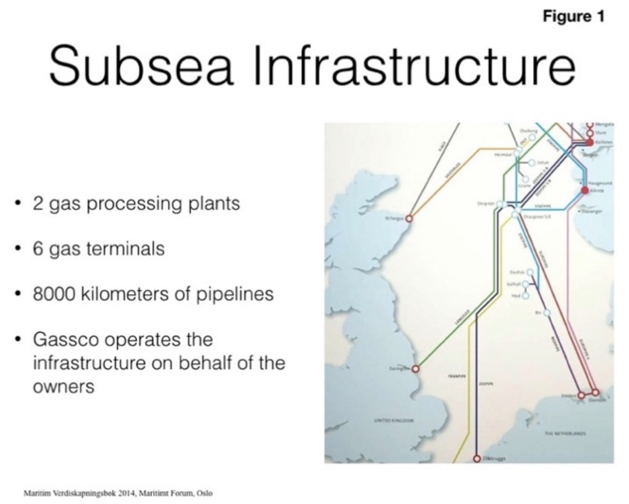
The report is necessarily a snap-shot of a business and a technology that changes fast. The content has been checked to verify that our account of the basic facts is accurate as a description of the period studied. We are especially indebted to Sveinung Soma of the subsea contractor DeepOcean for his comments.

Jan R. Jonassen is responsible for subsection 7 on the role of multiteam system of leadership on board and for the conversation about the future of the IMR business with Sveinung Soma of DeepOcean (subsection 9). He has also taken all the photos.

1. Introduction

Outside the coast of Norway, we find the world's largest subsea infrastructure, which transports natural gas and oil from offshore installations and wells to the mainland and to other countries. This infrastructure requires extensive inspection, maintenance, and repair, or IMR operations. Such operations can be performed from rigs, but the most cost-effective and flexible method is to use specialized subsea vessels.

Figure 1: Chart of the subsea infrastructure on the Norwegian Continental shelf



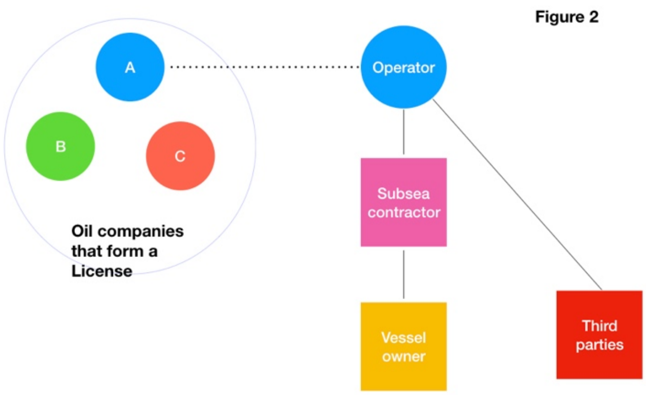
Groups of companies apply for the right to explore a section of the sea bed for oil and gas, and to extract the resources discovered. Such groups often consist of several owners that organize into a 'licensee consortium'. In everyday language both that consortium and the field that they control are referred to as 'the License'. One of the oil companies in the License also takes on the role of 'Operator' to organize and execute exploration, production and maintenance of the field in question. Here, we focus solely on the inspection, maintenance and repair side of operations. IMR operations have developed into a business in their own right.

The IMR business is organized as a supply chain; driven by the need to keep costs low, to spread financial and operational risk, and to create effective ways of making new technology available. This is reflected in the organization of each operation. For example, vessel owners shoulder the expense of specialized vessels, and are traditionally encouraged to do so by the promise of traditionally long contracts[2]. To conduct IMR operations the operator typically hires a subsea contractor who in turn hires a specialized vessel with its crew from a shipping company (the 'vessel owner'). On shore, the 'licensee consortium' (which owns a portion of the subsea infrastructure) assess their needs and commission the work that they want through the oil company operating the field. The client representative is the operator's liaison officer

[2] This arrangement concerns Statoil contracts in our material.

onboard. This configuration of companies was basically the same for all the vessels that we studied during our research. The vessels were on long contracts with an oil company, and the vessel where we conducted our field study was in service all year round. This pattern is still true for major operators, but the more minor operators that have entered the market in recent years also hire vessels on shorter leases on a spot market.

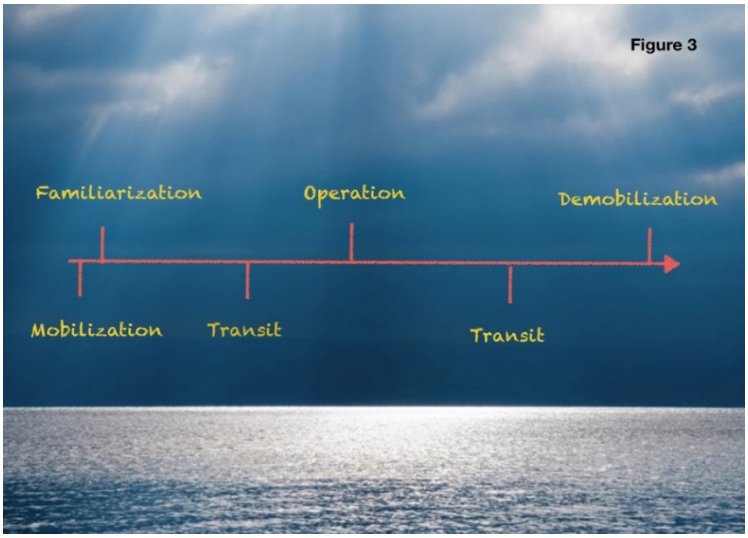
Figure 2: A typical configuration of companies



Specialized IMR vessels are both means of transportation and mobile knowledge organizations that perform operations at a destination. A vessel may have some 70 people on board belonging to up to five different companies. The IMR trips that we studied lasted for two weeks, and one or more operations were conducted during each trip. Highly simplified, we can say that each trip followed the pattern outlined in Figure 2. It started with mobilization and a partial crew change. For the beginning of the trip, the vessel served as a means of transportation. In transit on its way to a site, time was spent for preparation of the operation and for regular maintenance of the vessel. Upon reaching the site, often adjacent to a fixed installation such as a rig, the vessel was transformed into a scaffolding to perform subsea work from, held in suspension over the site by dynamic positioning technology.3 When shifting to dynamic positioning mode, an organizational shift also took place. All relevant resources on the vessel were put under the temporary command of a shift supervisor to perform the inspection, maintenance or repair operation. After the operation had been carried out the vessel entered into a new period of transit and went to port for new supplies and crew changes. At the end of a trip, the crew got ready to hand over the vessel to the next crew in demobilization. After two weeks, the operational crews were changed. The marine crews changed every four weeks.

3 Here, we have assumed one trip to perform one or several operations, but it happens that vessels are relocated on short notice to take care of business in other areas than originally planned.

Figure 3: Outline of an IMR trip



In the following sections we will explain in more detail how the IMR trips were organized and conducted. We will begin by looking at the context in which these operations took place and the preparations that happened on shore. Next, we will introduce the vessel technology and the onboard organization. We take Østensjø's Edda Fauna (the vessel we visited on the first field study) as our exemplar case, but we will also draw on other data. We describe an IMR trip chronologically in a non-technical language (for a technical overview, see Jens Chr. Lindaas *Kompendium i undervannsteknologi*, HSH 2013). Along the way, we will include vignettes based on our interviews and our observations to give the reader a more vivid idea of this world. In conclusion, we will discuss what issues our observations raise for practice and for research and point out some new developments since our data collection took place.

2. Context

Soon after substantial off-shore oil and gas reserves were discovered, Norway declared sovereignty over the Norwegian continental shelf (1963) and the petromaritime business began developing. The main activities were, and remain, *exploration* (the discovery of new resources) and *exploitation* (production of oil and natural gas). The central nodes of the offshore infrastructure are the production wells, traditionally operated from oil rigs. The biggest installations have adjacent living quarters on separate rigs.[4] From these central nodes, a system of pipelines, compressors and pumps connect the offshore wells to land in several countries. The infrastructure consists of close to 8000 kilometers of pipelines, two processing plants and six terminals for natural gas. It is operated by Gassco from its base on

4 The trend is for new fields to be operated from subsea installations on the seabed.

Karmøy, in Western Norway. Gassco takes care of the daily operation and the development of the infrastructure for the owners and oversees how gas and oil is transported through the system.

The installations get supplies and equipment from supply vessels, while the crews are normally flown back and forth to the rigs in helicopters. In addition to the larger, permanent installations, some work, exploration in particular, is done from moveable rigs ('floaters') and specialized vessels. When oil rigs are moved, there is often a need for anchor handling, performed by vessels designed for that purpose. Construction vessels of different kinds are used when new installations are put together using modules constructed on shore, or if major changes are to be made on existing installations. In 2014, the Norwegian offshore fleet comprised some 600 vessels in all categories: offshore service vessels, seismic vessels and subsea vessels (Maritim Verdiskapningsbok 2014, Maritimt Forum, Oslo).

IMR operations in the petro-maritime business

Within this bigger picture our focus is on subsea IMR (inspection, maintenance and repair) operations performed on the subsea infrastructure, in our case performed from specialized vessels. The purpose of these activities is to maintain a sustainable flow of oil and natural gas from subsea wells. Components on the seabed are often organized into modules and attached to the steel frames ('templates'). A unit together is often referred to as a SPS, a subsea production system. When a component fails, it can be replaced or repaired.

- *Inspection* activities are performed to document the condition of a seabed installation or to map the top few meters of the sea bed to prepare the ground for new pipelines and other installations (this is different from the surveys used in the exploration phase of an oil field, which go much deeper).
- *Maintenance* interventions can be performed on the well itself or on equipment on the seabed steel frame (the 'template'), for example for routine replacement of parts that will wear out.
- *Repair* interventions are needed when equipment on the seabed has been damaged or is no longer working properly. An example of damage happened during the maintenance of a well. A Blow-out preventer (BOP) (a big valve weighing 200 tons) had to be moved and tore off a hatch on a seabed installation. Such damage can be

repaired by IMR vessels using Remotely Operated Vessels (ROVs).

IMR operations are of a smaller scale than those performed from construction vessels and happen more frequently. Earlier, such work was performed from floaters and from modified supply vessels and rigs. From 2008-2009, purpose-built vessels began to take over. From the shipping companies' perspective, it made sense to continue offering multipurpose vessels rather than more specialized vessels that could only service a narrow market segment. From the oil companies' perspective, however, purpose built IMR vessels would be able to take on more kinds of relevant operations and be able to tolerate higher waves and therefore have significantly lower idle time. Even if their day rates were higher than for a multipurpose vessel, the IMR vessels would outperform the multipurpose vessel through this higher availability. Statoil therefore suggested designing and building such vessels and created an incentive for the shipping companies by offering longer contracts. An oil company veteran explained that:

> We [Statoil] acknowledged that in order to attract the industry to invest, a long-term contract had to be offered. We deployed all our experience in developing more comprehensive specifications that we had ever done aiming at constructing a new vessel that would lift the industry to a higher level. The carrot was to award a 5-year contract and a 3-year option.

Contractual partners and frameworks

When a section of the Norwegian continental shelf is opened for development, oil companies can apply for a "License".[5] Fundamentally, a License means the permission awarded by The Norwegian Ministry of Energy to explore and / or exploit a designated field in Norwegian waters. The Ministry of Energy decides which companies may participate in a License, and the size of their individual shares of that License. This group of owners of a field is an organization in its own right, with its own employees. That group is also often referred to as *the License*.

The Norwegian Ministry of Energy appoints one of the oil companies as *Operator* for the License on behalf of the License partners. The Operator is responsible for exploration and production. Statoil, as the dominant company in Norwegian waters, is often both an owner in a License and its Operator. Statoil employees may therefore find themselves in roles both in

5 The contractual arrangements of the oil and gas business are highly complex. Here, we just aim to outline some basic issues relevant for IMR operations.

the License organizations and in the operational organization.

With the development of a field follows the development of the infrastructure, and the License owns installations and pipelines. The License itself primarily takes on a role as the *task owner* of IMR operations and defines the issues that need attention, and their priorities. The functional IMR branch of the Operator's organization sometimes referred to as the *process owner*, acts as a client with subsea contractors and other suppliers, organizes the resources in response to different licenses' needs, and oversees the quality of the services that the suppliers provide. This division of labor enables the process owner (in our example Statoil's IMR department) to enter into long-term framework contracts with suppliers of goods and services that are put to use for many licenses. The rationale for long-term framework agreements is to reduce transaction costs, and to maintain and further develop working relationships to continuously improve the productivity and safety of operations.

The supplier contracts fall into several groups. The *prime contractors* are the subsea contractors (for example *DeepOcean*) that are in charge of the subsea operations on the vessels. Secondly, specialized service suppliers are also awarded long-term contracts, but they only join IMR trips when they are needed. Some of these suppliers have direct contracts with the oil companies (for example, Halliburton and FMC are hired directly by Statoil to assist in cleaning wells and replacing large modules on the sea bed). When such suppliers are present on the vessels, they are referred to as *third parties*, since the supervision of their work is often given to a prime contractor during an operation.[6] Most importantly, the subsea contractors hire the IMR vessels from a vessel owner (in our case, the Edda Fauna from Østensjø Shipping Company) in a second-tier long-term contract that mirrors the subsea contractor's contract with the oil company.

Onboard, these contractual arrangements are reflected in the organizational structure. The captain is in charge of the vessel and its safety, the offshore manager is the highest officer of the subsea contractor, and the client rep (and, in some cases, an additional license rep) are liaison officers for the operator oil company.[7] These three players negotiate issues of

6 Third parties may be present a consequence of maintenance contracts for equipment that they originally supplied. As technology evolves, questions often arise about these relationships. There is a tendency for personnel from subsea contractors and even maritime personnel taking over functions that have been supplied by third parties.

7 While the client rep is not formally a leader, third parties technically report to him when they are

contractual importance when they arise, and, if they cannot resolve them locally, they refer questions to their respective shore organizations.

Regulatory regime and proceduralization

The Norwegian oil industry is highly regulated by the authorities and scrutinized by the media, especially when it comes to safety. The regulatory regime makes a contractor responsible for the HSE levels of its own organization *and* of its subcontractors. The big players have invested a lot in technical solutions, educational campaigns, and in implementing safety procedures. The biggest player, Statoil, espouses the *safety-first principle*. The principle; that anyone who senses danger can put an operation on hold until the concern has been checked, is widely known and is now espoused by all companies operating on the Norwegian continental shelf.

At the same time, the oil business is very expensive and large in scale, so small delays and other drops in efficiency can have a great impact financially. The push to work effectively and efficiently is therefore great. Operations are executed through the aforementioned web of contractors and subcontractors. The pressures for safety, effectiveness and efficiency have led to a very voluminous system of plans and procedures (to describe what is expected to happen) and documentation (to describe what has happened).

The high degree of regulation by the authorities is matched by a high level of proceduralization within companies (and groups of companies). The amount and the level of detail of plans and procedures can be overwhelming to a newcomer. The same goes for how incidents are reported and processed. The execution of each IMR operation is documented in detail, and all the subsea work is recorded on video. But even with careful planning, unexpected events will inevitably occur. To handle this, plans may need to change. For these situations, there is a procedure to change procedures, called the *Management of Change*. This stipulates who needs to be involved, how to revise a procedure, and who needs to sanction the revision. As we shall see, daily life in operations also requires improvisation beyond formal changes of plans.

The extensive proceduralization is the subject of much debate both in the business itself and

onboard since their contract is with the oil company directly.

amongst scholars[8] . There is a potential risk that attention can drift from containing primary risk towards avoiding liability and blame.

Proceduralization is also encouraged by the overall regulatory regime and legislation, laid down in national law, and also governed by international treaties and recommended practices and standards (such as ISO, Norsok, Asme, DnV). An additional layer of complexity that affects the IMR business is that it is subject to both maritime regulation (the IMR operations are conducted from vessels) and to petroleum rules, regulations and recommended practices and standards. For example, Norwegian maritime law stipulates that the captain of a vessel is ultimately responsible for the safety of a vessel and its crew (oil and gas operations have their own set of rules).

The translation of needs and requirements into plans

The responsibility for maintaining production with minimal disturbances lies with the operating company of a field development license. A License rep explained:

> We are the owners of equipment on the sea bed…. This means we must make sure that the installation is available for the production of oil and gas at any time. If we find an error in the production system that may cause a halt in the production, we initiate a plan to correct the failure.

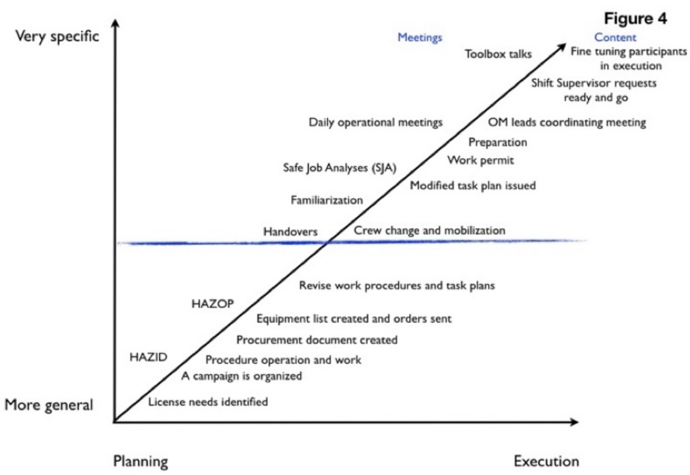
In many cases, people on the offshore installations are the first to notice signs of existing or potential disturbances. When, for example, the operating crew in the control room onboard a production platform notices an anomaly, they log it as a hazard notification. The notification is immediately tagged as 'ignore', 'save' or 'act' indicating if the discrepancy can be tolerated, saved to be gathered with others before action is taken, or that some action must be taken immediately. The subsea production system has multiple redundancies (backup systems), so the urgency of a need for repair depends on how many backups are left when an anomaly occurs. The state of the infrastructure is also monitored from the shore, and specialized units assist in defining risks and planning interventions. For example, a specialized 'reservoir group' helps monitor and plan interventions to maintain the oil wells. The tendency is to let less problematic deviations wait and accumulate enough work to warrant the mobilization of a vessel. At any given time, 50 to 100 notifications may be in the log. Logged failures or signs of possible failures eventually lead to a mobilization.

8 See, for example Corinne Bieder and Mathilde Bourrier *Trapping safety into rules* (2013)

Licenses determine the needs for IMR operations for their fields, and communicate these to the Operator's IMR department, who in turn plan how to best use the available resources to service the needs of multiple fields. IMR operations are grouped into 'campaigns', and many trips may be needed to complete a campaign. A campaign may cover several templates and parts of a field. The plan is generated on the basis of an analysis of the existing infrastructures' technical reliability, on the incoming reports from the installations and long-term maintenance plans. A campaign is a complicated affair that can be subject to delays and other difficulties. Since the License has a database of logged failures they can make use of this and identify smaller IMR tasks that may be executed during time periods that would otherwise be idle. The Operating Company must optimize operations for the long term, but also respond to more urgent needs, and adapt to changes in weather conditions.

In Figure 4, we give a simplified overview of the planning and execution process, reaching from the more overall plans to those that pertain to an individual trip. The blue line indicates the approximate point when the vessel leaves port.

Figure 4: Planning and execution



Starting from the more general planning, each License will request IMR work in their field from the operator, who develops a *work program* that articulates the initial plans and the scope of work for each field installation. The work program is sent to the subsea operator (the prime contractor), and their shore organization creates more specific plans. This is the beginning of a process by which identified needs are translated into more and more specific plans to be executed in an upcoming IMR operation. The first stages of the process take place on shore. As an IMR vessel embarks on a trip the work continues on the vessel and people closer to the actual execution of an operation get involved.

The subsea contractor's shore organization develops a *generic procedure* for each operation. This collection of documents is produced to describe the *scope of work* and the sequencing of the operation on a specific trip. The process of developing a generic procedure also follows certain procedures. Generic procedures are typically repeated from one operation to another. When needed, specific work procedures are developed for each Scope of Work. At an early stage a *Hazard Identification Study (HAZID)* is carried out. The HAZID is an early 'risk assessment' based on the Scope of Work and the 'concept of solution' (i.e. the proposed method) and may involve comparing several alternative ways of going forward.

The generic procedure goes through revisions, internally in the subsea contractor's organization and with the client organization. It copies many elements based on earlier experience with similar operations but takes care to integrate specific considerations for each new operation. To implement actions to remove or reduce risks that have been identified in the HAZID to an acceptable level a *Hazard and Operability Study* (HAZOP) is performed on the revision 0 of the procedure.

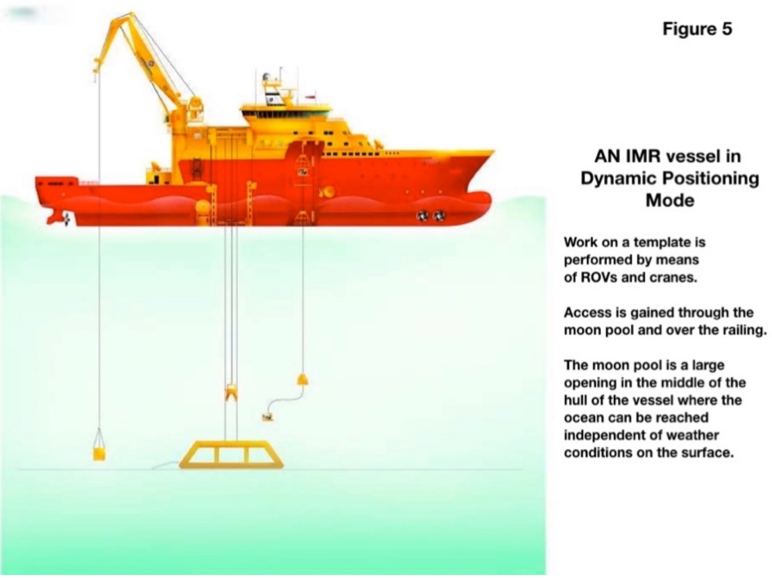
When the generic procedure is completed, it serves several purposes. It gives a full road map of the trip, with much relevant information in one place describing the sequence of the trip in operational detail. It also stipulates standards for safety, acceptable weather windows, and requirements for how crews must be familiarized with the upcoming work and provides contingency plans for what to do in case of known, potential failures or malfunctions.

The *task plans* form an important subset of the generic procedure. It defines the 'operational steps' used in real time during the operation. Typically, more than one operation will be carried out on a trip, and task plans describes each discrete operation. This is the "playbook" for the people directly involved in the execution of an operation. As an example, a task plan for a module replacement contained a to-do list of forty-seven items covering communication (who to notify and involve at what stage), technical safeguards and double-checks, safety checks and work permits, and detailed descriptions of each physical step and their sequence.

3. The Vessel

A modern IMR vessel is a high-tech environment that is equipped to perform subsea operations by Remotely Operated Vehicles, or ROVs. On arrival at a location, the vessel is fixated by means of ‘dynamic positioning’ (DP) technology. A satellite-based navigation system locks the vessel into position using powerful thrusters, but without the use of anchors. The space beneath the vessel is therefore open, making the operation of the ROVs easier.

Figure 5: An IMR vessel in dynamic positioning mode



The vessel has openings in its hull (‘moon pools’) through which equipment may be lowered and hoisted. The ROVs come in many shapes, but, in general, a robot can be thought of as a mechanical lobster, with two arms (‘manipulators’), and with cameras and lights as its “eyes”. Two pilots sitting in a control room on the vessel ‘fly’ the ROVs and follow the work on screens. They can perform smaller tasks on the installations on the sea bed (e.g., replacing a valve) or assist in more complex operations (e.g., a ‘scale squeeze’). For each dive, the ROV carries a selection of relevant equipment, stored in a toolbox.

The Edda Fauna is a high-tech vessel purpose built for IMR operations. Both in transit and in Dynamic Positioning mode at a destination, the vessel is operated from the bridge. The bridge is a big space with a clear view in all directions. There are separate consoles for operating the vessel in transit and in DP mode. It has seven diesel engines that power electrical generators that in turn power the eight ‘thrusters’, the actual propeller engines that drive and stabilize the vessel. The thrusters can move the vessel in all directions, making accurate navigation in small areas for Dynamic Positioning possible.

The technical core of the operation is the remotely operated robots that have replaced much of the work performed by divers in earlier years. These ROVs are operated by pilots that work in pairs. The ROVs can have two manipulators ('arms'), one with more power, and one with greater accuracy. This vessel is equipped with three ROVs: two working vehicles and a smaller observation vehicle.[9] When submerged, the ROVs are connected to the vessel through cables called *umbilical cords*. The ROV pilots sit with their supervisors in a central control room in the vessel. The Shift Supervisor has a separate control room (in the case of the Edda Fauna) next to ROV pilots' room.

A 100-ton main crane on deck is attached to the side of the vessel. It is used to retrieve and lower heavy objects (operated by the marine crew). The vessel also has a large hangar on deck to protect from bad weather and the cold of the arctic areas. Some heavy lifting operations are performed from the hangar. A tower crane (also called an MHS, a Module Handling System), is operated by subsea operational crew and plays an important role. The components that are attached to the template on the seabed make up the SPS, the Subsea Production System. The purpose of the module handling system is to be able to retrieve and lowers tools and equipment to and from the template in controlled way and to eliminate pendulum motions in the horizontal plane. For this purpose, the MHS moves components to the center "moon pool" (a chamber protected within the hangar, 8 meters in depth, through the ship's hull) and uses 'guide wires' that have been fastened to the templates on the sea bed to lower components to a safe landing on the template. Two smaller cranes raise and lower the ROVs through moon pools on each side of the vessel, and two minor cranes on deck are used to handle special equipment.

On the Edda Fauna, tanks for special liquids and pumps are integrated in the vessel, operated by mechanics under the command of the chief engineer.[10] This equipment is used for scale squeeze operations where wells that have become congested need to be cleaned.

The vessel is also well equipped for life off duty. Officers, crew and operational crews share

9 The number of ROVs operated from a vessel varies. One vessel that we visited had seven ROVs.
10 On the modified supply vessels used earlier tanks were brought on board when they were needed. At the time of our field study (2009) this had not yet settled into a fixed pattern.

one mess and eat the same food. There is a separate cabin for each crew member, or two crew members that work days and nights alternate. The vessel has meeting rooms, a cinema and a gym. There is no WIFI network, but the crew can still go online on dedicated PCs with satellite connections.

A captain identified the *telephone* as the single most important communications tool on the vessel. This is three systems integrated into one: satellite telephones, cellular telephones (useful when close to shore), and intercom. Each of the officers, including third party personnel, can dial each other directly by internal numbers. The calls are routed through an automatic central. If the person called is not on duty, the call is patched through to his counterpart.

Communication between the bridge and hangar and deck go through *UHF*, a wireless radio system with a limited number of open channels.[11] All people on deck have a handset, which is a little bigger than a mobile phone. Voice communication between the bridge, the crane and MHS operators, and the ROV control room can also go through the *Clearcom*, a cable-based intercom, when undisturbed communication is called for. This can be important when the vessel lies near an installation and the operation is in progress.

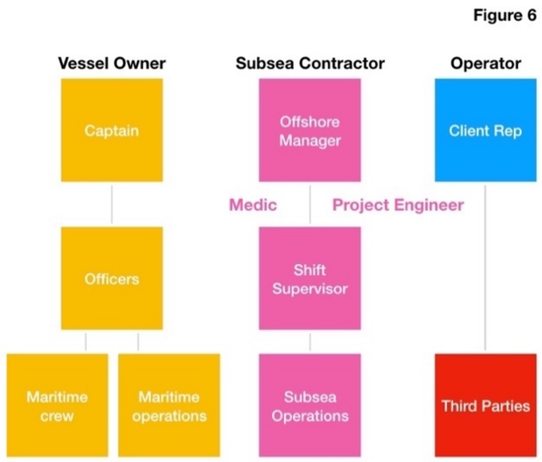
The standard wireless radio system for most vessels is the *VHF*. In our case, this is used mainly for communication between vessels, between a vessel and a rig or platform, to control stations on shore, and in life boat emergency exercises. The bridge can also communicate with people working on deck through this system.

4. The Organization

On a vessel such as the Edda Fauna, some 70 crew members are onboard for the duration of a typical two-week trip. Such a vessel is as much a high-tech platform to perform subsea work at a destination as it is a means of transportation. The organization of our IMR vessel is best described as three parallel hierarchies that reflect the contractual partners.

11 The sender and receiver need to agree on which channel number to use, and to have a back-up plan for which channel to move to if they get disturbed by others.

Figure 6: The Organization



The maritime organization is similar to what we find on other types of vessels. The *captain* leads the maritime officers and crew. The crews are organized in departments (bridge, deck, catering, and engineering), each lead by an officer. The captain oversees navigation and leads the vessel in transit from the shore to the destination and back and makes sure the vessel is kept in position at the destination during the execution phase (most often by means of dynamic positioning). Decisions on when and how it is appropriate and safe to enter, remain in, or abort the steady state over the location are the captain's call. The captain also interprets early warnings on wave height, weather, suspected gas leaks and acts on them. Under maritime legislation, the captain has the overall responsibility for the vessel and all personnel on board, and its safety, and the power to override decisions of all the other players, even the owners, in matters of safety.

The captain can delegate authority for navigation and more specific tasks (e.g. for making sure that the chemicals loaded into the onboard tanks come with approved certificates and data sheets) to the *first officer* on duty. The first officer also oversees maintenance, coordinates the operation of the vessel during transit and in port, and is in charge of the marine deck crew (*deck hands* and *main crane operators*). The first officer also manages the important interface with port authorities, including compliance with the ISPS code[12].

12 The international safety rules for harbor areas.

The *chief engineer* leads two engineers that work in shifts, 2-4 additional mechanics and one electrician. These workers maintain and operate the vessel's engines. Since the vessels have built-in pumps and tanks to service some subsea interventions, operating these devices at times becomes an additional task for the engineering department[13].

The *chief steward* leads the catering department, with six or seven employees that take care of meals and accommodation. In their work the cabin stewards are active in large parts of the vessel and have contact with people across departments and companies. In total, there are some twenty-five people in the maritime part of the organization.

The *offshore manager* leads the operational organization, and, when the vessel arrives at a destination and goes into dynamic positioning mode, he oversees the execution of the operation. He maintains ongoing contact with the captain and the client rep.

On his staff, the offshore manager has two people in advisory roles. The *project engineer* is important for refining and implementing the plans that have been developed by the subsea operator's engineering department on shore. Conditions on the site may be different from expected, and plans need modification. New, minor operations may come up that have not been planned ahead of time. In such cases, the project engineer develops new task plans. The project engineer also plays an important role in taking care of much documentation, and in the processes that involve the crew in the final preparations before the execution of an operation. He facilitates Safe Job Analysis (SJA) meetings for risk assessment that take place prior to the execution of each task. Last, but not least, the project engineers also tend to rotate between the onshore engineering department and offshore trips. They have an overview of the bigger picture of an ongoing campaign (a group of many trips and operations) that many of their coworkers do not have. They form an important link between sea and shore.

All vessels in our material also have a hired *medic* on duty who divides his or her time between taking care of first-aid and other medical needs (in this capacity he reports to the captain), and to duties as an HSE advisor for the offshore manager. The medic has some uncommitted time that is used to monitor HSE matters and take ad-hoc initiatives.

13 At the time of our investigations, these arrangements had not settled into a fixed pattern. There was high turnover amongst marine deck crews, and both engineers and officers stepped in to operate the pumps in some cases.

Table 1: Roles and affiliations

Role	Affiliation	Description
Captain	Vessel Owner	The captain is in charge of the vessel and its crew and oversees navigation and safety.
First Officer	Vessel Owner	Next-in-command for the captain. Special responsibility for maintenance, relations with the base when in port, and marine deck crews.
Second Officer	Vessel Owner	Next-in-command for the first officer.
Tower Crane Operator	Vessel Owner	Operates the main crane, and reports to the first officer.
Chief Steward	Vessel Owner	Leads the catering department.
Catering personnel	Vessel Owner	Operate the mess and keep living quarters and communal rooms clean.
Chief Engineer	Vessel Owner	The officer in charge of the vessels' engines and pumps.
Engineers	Vessel Owner	Report to the chief engineer.
Mechanics	Vessel Owner	Report to the engineer on duty.
Client Representative	Oil Company's IMR branch	The onboard liaison officer for the oil company's IMR branch. Monitors the ongoing work on the vessel.
License Representative	Oil Company that acts as the main Operator	Occasionally the consortium that owns the License has its own representative onboard, to oversee the place of the ongoing operation in the wider context of an on-going campaign.
Offshore Manager	Subsea Contractor	The offshore manager is the highest-ranking officer of the subsea operator company on the vessel.
Project Engineer	Subsea Contractor	An aide to the offshore manager who keeps track of current and upcoming Task Plans and maintains continuity from on-shore planning to offshore execution. The PE knows each plans' place in the bigger picture of ongoing and upcoming campaigns.
Medic	Subsea Contractor/Vessel Owner/ HSE provider	Assists the captain on health issues, and assists the offshore manager in matters of health, safety and environment. Primary affiliation: with an HSE provider.
Shift Supervisor	Subsea Contractor	Controls and coordinates all resources in the execution phase of an operations.
ROV Supervisor	Subsea Contractor	Leads the ROV teams and is responsible for pilots' learning and development.
ROV Pilots	Subsea Contractor	The pilots 'fly' the subsea, remotely controlled robots (ROVs) and are in charge of the maintenance of the ROVs.
Deck Foreman	Subsea Contractor	Leads and coordinates the operational work on deck.
Riggers	Subsea Contractor	The operational deck hands reporting to the deck foreman.

The offshore manager tends to take a high-level perspective of the trip as a whole and delegates the minute-to-minute execution of each operation to the *shift supervisor*. The shift supervisor stays in his control room during the execution of the operation and focuses his efforts on coordinating the individuals and teams from all three hierarchies, in what we have labelled *"The Operational Multiteam System"* (the operational multi team system is an important feature of the organization which will be discussed in more detail). The core of that system is the ROV team. *ROV Supervisors* lead pairs of *pilots* who "fly" the ROVs from a control room on the vessels. Alongside the marine deck crews, the operational organization has its own people on deck to support the subsea operation. The operational deck crew stands under the supervision of a *deck foreman*. He oversees the work of the *riggers* (deck hands), the *MHS (tower crane) operator* and the *crane operator*.

Photo 1: An ROV pilot at work

The *client rep* is the liaison officer onboard from the oil company that acts as operator for a License.[14] Technically, the client rep is not a leader, but is important since he oversees the trip and the execution of the operations for the Operator. These third-party specialists are brought in on some trips that require their services. An example is Halliburton, who assist in scale squeezes, and FMC, who design and operate large tools and are involved in replacing components of the Subsea Production System (SPS). The oil companies in our research hire these specialists directly, and not through the structure of contractors and subcontractors that is used otherwise[15]. For this reason, they are called third parties. The historical background for this is sometimes that a third party, such as FMC, have supplied parts of the SPS originally and entered into maintenance contracts for them at the same time. In practice, though, these resources are put under the command of the shift supervisor in the execution phase of an operation.

14 The Client Rep is at times accompanied by an engineer on his visits to the vessel. In such cases, the Client Rep will work the day shift while the engineer will work the night shift.
15 The reasoning for this seems to be a wish to maintain tight controls over the technology and the people involved in the work. For example, the module companies manufacture the templates, so it makes best sense that they participate in maintaining them.

5. Risk and Risk Mitigation

Subsea oil and gas operations are creating high revenues for the companies involved. The benefits for the Norwegian society come through high taxation and direct and indirect interests of the government in parts of the oil and gas business. The production of oil and gas is controversial for perpetuating an economy based on carbon emissions. Producing oil and natural gas is also an energy-consuming activity in itself, for example, operating the pumps in the subsea infrastructure leads to significant CO2 emissions. Several serious accidents have led to loss of life and environmental problems, and there have been many examples of near misses. All of this has, however, also led to a very high attention on containing risks to people and the environment (as well as to containing financial risk), so much so, that these concerns run through the days of IMR operations such as the ones we are focusing on here. In this section, we will try and give the reader a brief overview of the risks involved and efforts on risk mitigation. We will look again on aspects of risk and risk mitigation throughout the discussion in the rest of the document.

The Norwegian Continental Shelf is known for rough and unstable weather conditions. Wave heights can reach seventeen meters. Wave height is one of the most critical constraints on an operation, more because of the impact high waves can have on the use of the tools for the subsea operation than for the vessel itself, which is more robust. If significant wave height[16] becomes greater than five meters, the operation is stopped.

Amongst the gravest potential risks for an IMR vessel are gas leaks below the vessel or possible collisions with oil rigs. For example, if a gas pipeline were to rupture at the installation, and a mass of gas bubbles were to rush to the surface underneath the vessel, the vessel could lose its buoyancy and instantly sink. Measurement instruments are in place to sound warnings if there is too much gas in the water.[17] This example illustrates vulnerability when the vessel is in DP mode, and needs to escape from the site in a hurry.

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[16] A term from oceanography. It defines when a certain percentage of waves within a defined time window exceeds 5 meters, and thus is considered 'significant'.

17 We know of one instance (not caused by crew error), where the instruments failed to pick up such danger, but a deck hand noticed bubbles in the water and raised the alarm. The captain aborted the operation and brought the vessel to safety in time.

While operations are very rarely touched by such dangers the teams that carry out an IMR operation are exposed to physical risk. The deck is the most dangerous location on the vessel, especially during the mobilization and the operational phases. Many heavy objects and containers with chemicals are stored on deck. Several activities often occur in parallel, including the lifting or handling of dangerous objects. Safe operation in a limited and unstable space requires a high degree of awareness on the part of all team members, as well as smooth coordination between the operational and marine crews on deck. The sub-sea teams that fly the ROVs, and the tower crane operators who must lift and lower tools and equipment with great accuracy, operate within the closed environments of their respective control rooms. While these groups are more protected from the elements than the crews on deck, mistakes on their part can potentially lead to grave consequences.

Faced with these risks, risk mitigating measures have evolved that we may group into three, broad categories; *redundancies*, *routines and procedures*, and *skills and competencies*.

Like many other high-tech systems, the vessel has a number of redundancies, the basic principle being that if one system fails, there are one or several alternatives to fall back on. The several communications systems mentioned in the section about the vessel is one example of redundancies that are built into the technical design, and there are many others.

The most fundamental backups on the vessel have to do with propulsion and power. The seven diesel engines work independently of one another, and the vessel can move with just one of the thrusters. An illustration of how this can be important is that the Edda Fauna had trouble with two thrusters over the first eighteen months in service.

A particularly bad scenario is if all automatic and electrical systems fail while a scale squeeze operation is in progress (a “black ship” situation). In this scenario, a large hose (a “black eagle”) connects the vessel to the template, and the active ROVs are connected by ‘umbilicals’. A hydraulic cutter system can sever the hose, and automatic systems will cut loose the ROVs. There is an emergency power generator that produces electrical power for a limited time to enable the operators to get an overview and try to recover the ROVs and, possibly, the tools.

On arrival at a location for subsea work, the vessel switches to Dynamic Positioning mode to keep the vessel steady without the use of anchors. The vessel has always multiple systems for maintaining control and staying on location. There are two operational consoles on the bridge that work independently of one another. The switch board on each of them is divided into three zones to keep three control systems separate. Each of these have their own reference system to keep track of exact location (either differential GPS based, or based on a physical transponder placed on the sea bed). The vessel also has three gyro compasses and three units to measure pitch, roll and heave.

The comprehensive procedures described in section 2.3 are also a means for risk mitigation, in that they seek to establish predictability and to facilitate coordination. Reflecting on an example of improvisation outside normal procedures, a shift supervisor commented:

> I try not to deviate from what is written down. If it's not written down, then I'll want confirmation from somebody else before I will deviate from that path (…) I'm not going to deviate from what I'm supposed to be doing, especially in this industry, because then it opens up a whole new can of worms because I don't know what we're doing and, therefore, other people don't know what we're doing (…) because at the moment everybody has a set sequence of the way things are going to go and people know, hopefully, what they are going to do next.

Individuals socialized into the world of IMR operations can develop skills and competencies that are useful means of risk mitigation in their own right. In our research, we noticed how many of our informants had an overview of the operations that they were involved in that far exceeded their own area of expertise or responsibility - they seemed to 'know more than their place'. This capacity seems to stem from experience, training, procedural discipline and collective briefings of the people on board. One may argue that such "redundant task knowledge" can function as a back-up system. For example, people in various functions need special courses and permits. Such knowledge and the briefings in the familiarization meetings at the beginning of each trip may also shape some shared knowledge that makes the system less dependent on single individuals. Procedures always have an element of managing risk. As an example, the conversations in SJA (safe job analysis) meetings are carried out routinely before the execution of task plans. SJA meetings are attended by all members of the actual operations and are normally managed by the field engineer. They can create moments of collective attention to risk, and a forum for raising concerns. Socialization and experience teaches members of the crew procedural discipline, make them attentive to weak signals of potential danger, and also gives them the insight that procedures alone cannot address all contingencies. Confined to the isolated world at sea officers and crew members combine procedural discipline with the ability to improvise and to wear several hats, as the following example of the role of the medic can illustrate.

Medics as assistant risk mitigators

Medics are trained nurses that divide their time between two main duties, as health workers, and as HSE advisors. Most are employed through an HSE temp agency that specializes in leasing personnel to shipping companies and to the oil industry. Their jobs tend to be stable, with the same configuration of vessel owner and subsea contractor. Those companies share the cost of the medic's salary. In the temp agency, the medic reports to an MD on shore, and consults with a duty doctor when needed (e.g. diagnoses, medication with prescription drugs). In day-to-day work on the vessel, however, the medic will focus on the two main duties in the vessel organization.

As a health worker, the medic reports to the captain, who has prime responsibility for health and safety on the vessel. The captain relies on the medic (and the on-shore doctors) for advice and delegates most tasks to her/him. The medic maintains medical supplies and keeps the hospital in good order and performs checks on hygiene and drinking water. S/he trains and drills people recruited from the catering crews in first aid. The medic will prioritize assistance with injuries, illness or personal problems when such needs arise.

In her or his capacity as an HSE advisor, the medic assists both the marine and the project organization on board and works closely with the Offshore Manager. S/he participates in daily meetings (that often focus on safety), SJA meetings and risk assessments, daily operation meetings (being the secretary) and logs incident reports. The medic takes an active part in project and HSE familiarizations. With the emphasis that exists on procedures and documentation comes the need for secretarial work for the OM.

By design, the medic's day is not completely filled with pre-planned activities. Slack is allowed to improvise in the role as an advisor and motivator for productive HSE practices. Medics spend time walking around the vessel, to nudge people in the direction of safe work practices, and to stay sensitive to developments in work environment. They intervene both in small ways (e.g. pointing out missing safety gear) and more systematically (e.g. active conflict management). Some medics point out that success in the role as an HSE advisor may reduce injuries and illness.[18]

6. Mobilization

Typically, the vessel will call on a base every two weeks. Coast center bases are hubs for service, technology and training for the maritime industry, and many providers of services, supplies and equipment for the subsea industry have set up shop here. There are several such facilities in Norway.[19]

Prior to each upcoming trip a planning process has taken place in the shore organizations (see section 2.4) involving the License (or prime contractor), the Operator (or client) and the Subsea Contractor. The vessel owner is informed about the IMR operations that are to be carried out, the offshore field location, and the port of departure. The vessel owner then undertakes his preparations for the trip, which includes the mobilization of personnel, the ordering and loading of various supplies for the vessel, and the required preparations of a maritime nature. The Client, the License, and the 3rd parties (if required for the trip) simultaneously make their individual preparations.

Mobilization task plans are carried out, chemicals are ordered and transported to the dock for loading, as are the required equipment and tools. This is a huge logistical process with direct impact on the vessel's time of departure. A lot of things can go wrong along the logistical line. Our data shows that this surely is the case and departure is often delayed.

18 With the degree of freedom in how medics spend their time comes some impressions from others that they have a lot of idle time, and requests for their assistance with secondary duties such as social functions and lotteries. Some medics see these requirements (and requests for secretarial assistance) as going too far.
19 There are currently five under the umbrella coast center bases (www.ccb.no), but others are also in operation that vary in size and in what services they offer.

Photo 2: Cargo being welded to the main deck during mobilization

Prior to the mobilization, the captain should receive data sheets for all liquids to be loaded onto the vessel. This documentation can arrive just in time, or late, and can cause a departure to be delayed. The captain will not agree to leave port if these documents are not in place. The physical loading process is, however, the responsibility of the vessel crew supervised by the chief officer. Records of the goods that are loaded are prepared and the equipment and containers on deck are fixed (often welded onto the deck) and made ready for departure. From the Subsea Contractor, the shift supervisor and the deck foreman oversee the loading of the vessel. The overall responsibility for sailing with secured cargo is the captain's, a duty he often delegates to the first officer.

Personnel for the IMR operations are then mobilized and checked in on the vessel. Finally, a comprehensive check of the loaded goods is done by the subsea company's equipment controller based onshore. This process ensures that everything needed is in place as specified and that the equipment works adequately. Missing goods and malfunctioning equipment are reported. On the trip in this study, new modules to replace old modules at a field location did not arrive in time for the departure. These kinds of discrepancies lead to delayed departures, late arrivals at field locations, and reduced time available for carrying out the IMR operations.

The days of port calls tend to be very busy, some people in the catering department described it as 'inferno days'. Much attention is devoted to performing smooth handovers. The highly complex operations require precise coordination and knowledge sharing. In addition to the proceduralized steps and the division of labor and responsibilities illustrated above, the experienced people involved also take care in maintaining or establishing personal relations. For example, a shift supervisor explained that he made a habit of inviting some of the other people that he depended on for a meal to get acquainted. Specifically, about the deck foreman, he said:

> (…) one of the first that I try to establish contact with and try to get to know is the deck foreman. For he is my eyes and ears on what happens on deck. And that job depends on mutual respect. If I notice that this is an inexperienced, newly promoted, that kind of person, that suggests that I must spend more time out on deck to get the job done, you could say. (…) we are all different, for instance some personalities can be very, very capable deck foremen but poor on the human side. So those are things that I begin to form an idea about quite early.

Several of the other informants, captains and offshore managers also stressed the importance of taking care that information is communicated, and to make sure that the people at the receiving end have sufficient grasp of the tasks that they are taking over. In addition to the practical knowledge that experienced individuals make use of in communicating in organizational interfaces, some organizational arrangements also facilitate knowledge transfer through what we have labelled 'syncopated rhythms'.

Syncopated rhythms

To understand how subsea operations work dynamically we must extend our knowledge of the organizational structure and look at a number of interconnected processes. Each of these also requires interface management and handovers to secure an uninterrupted work flow. The basic building blocks are campaigns, operations, and trips. If we take a single two-week trip as our perspective, we also need to be aware of three other processes to understand how the organization works:

- Service periods – the work periods for each crew.
- Shifts – the time that crew members are on duty during a service period.
- Duty rhythms – the ways that the work is timed and split up *within* shifts or service periods.

When at sea, all personnel work long shifts, and have no days off. On this background, arrangements with relatively long breaks between service periods have developed. Different groups and companies have been able to negotiate different arrangements.

In our material, marine personnel work four weeks on and four weeks off. The subsea contractor's people work two weeks on and four weeks off. These differences in working conditions can be a source of tension.[20] The third-party personnel are organized to be on call for request from clients, so their rhythms are not synchronized with those of individual vessels.

The different 'wavelengths' of the service periods, may, however, also play a role in securing continuity, as one captain pointed out. For example, when a subsea operator crew signs off, the marine officers (on a 4-4 schedule) that remain on the vessel have knowledge that can be useful to the new subsea operator crew. Within the vessel owner's own service period arrangements, there is also a form of 'syncopation' which is intended to maintain continuity. While all work a 4-4 schedule, only half the crew gets replaced at each crew change. The captain will not change at the same time as the chief engineer and the first officer.

In similar ways, the patterns within shifts that we have called duty rhythms are syncopated to secure continuity through overlaps, and to counteract fatigue and monotony. For example, maritime officers and crews work 12-hour shifts, and in most cases, two people are on duty simultaneously. But they sign on at different hours, so that at an any given time a six-hour overlap is in progress. Other rhythms break a single shift into parts. For example, two navigators share a shift, following a common pattern of formalized leadership redundancy (with a second navigator available as a backup). Both in transit and in dynamic positioning (DP) mode at a destination, the navigators alternate in steering the vessel or operating the DP system. Similar arrangements exist for ROV pilots.

A mindful moment

The different team leaders and other key figures in our material were experienced and mostly well-coordinated. The following excerpt from a field log from one of the researchers is included to illustrate one of the less tangible qualities of this collective, their ability to stay on task while also being able to notice and deal with a potential weak signal of potential trouble. The meeting occurred during mobilization, and the participants were taking part in a group

20 For example, some people that we interviewed claimed that deck crews tended to seek jobs on rigs to find better pay and working conditions.

interview. One of the researchers acted as an observer, and the excerpt is from his notes.

> The team had gathered in a meeting room on the fifth deck of the vessel which was moored at a supply base. Outside, there was a steady hum of activity as the crew was getting the vessel ready for the next trip. Inside, a group interview had been in progress for over an hour. Some key operational leaders of the subsea vessel were present; the captain, the offshore manager, an ROV Supervisor, and a medic. The client rep, not technically a leader, but important as the liaison for the oil company, was sharing his views about the leadership arrangements on board. A researcher led the discussion, and I was observing.
>
> Suddenly, the humming outside was interrupted by an unfamiliar sound. The client rep paused for a brief moment, and his eyes went to the captain who looked at the offshore manager who stood up and went to the window. The ROV Supervisor rose and left the room. As he came back a moment later, he said something I didn't hear to the offshore manager before he sat down again. The offshore manager turned to the captain and they had a brief exchange before they both looked at the client rep and nodded. All of this took less than a minute. As this happened, the client rep's reflections on leadership issues continued at a slower pace, while part of his attention lingered on how the others were dealing with the unfamiliar sound.
>
> We outsiders had heard the new sound but only noticed it when we noticed how the insiders were paying attention. There was no drama. The group seemed capable of figuring out what was going on and making decisions using a portion of their cognitive capacity and with minimal talk. Their actions seemed coordinated and attentive without being high-strung. We outsiders felt puzzled, but safe.

7. The role of multiteam leadership on board

By Jan R. Jonassen

We have described the organization onboard an IMR vessel as multiteam system being too complex to be described as the strategies and behaviors of only one person. These leaders work in concert to be facilitating and contributing to flexibility and adaptation thus initiating collaboration between teams and individuals through interaction processes. This unique leadership model allows for and generates openness, transparency and the practice of basic values like respect and helpfulness.

Our research has revealed the following main results describing leadership and management within these offshore operations (Jonassen, 2015):

- Two main problem areas stand out: *unclear lines of communication and responsibilities* and *the impact of strong personalities* mainly negatively affected the collaboration between the top leader functions; captain, offshore manager and client representative (which formally is not a leadership position).

- However, this type of leadership constellation combined with delegation of running operational tasks, also opened possibilities of a freer leadership behavior, labelled informal leadership redundancy. Top positions and positions independent of work schedules (medic i.e.) may offer human support to individuals and teams regardless of organizational position.
- The organizational model generates openness and transparency building a climate which is a prerequisite for constructive sharing of learning within and especially between composite teams. One of the offshore managers illustrated: *The total competence stays within the team* and not within individual positions.
- The leaders within these types of operations particularly exposed three types of behaviors:
    - **They create intergroup relational identity within the total crew**;
      The challenge for leaders in subsea operations is to create or contribute to the creation of an overarching collective identity to facilitate the transformation of the organization from a diversified and more fragmented organization consisting of four or five individual component teams to an executive force of one major team supervised by one leader. Each of the leaders has their identity towards their original component team, but in the execution phase they belong to the overall team and are supposed to build on the collective identity without rejecting their component identity. This is possible by building and exposing a shared picture of future tasks and comprised organizing ideas on how tasks are realized by building on personal and commonly shared experiences. In practical daily work this involves support, using flexibility, integrating all and giving workable feedback.

    - **They engage in making sense of their messages and communication;**
      Conveying the meaning, purpose and understanding of the operations and the external environmental impacts, is critical to the total team performance. One important part of sensemaking for leaders is the turning of their objectives and intentions into followers' own preferences. This will give the crew a sense of ownership to the operations to be performed. The interviewees described this as: "To implant suggestions that felt like their own". Clarification of leader's messages has also proved to be of help in the crews understanding of the task

work. There may be only one opportunity for leaders to clarify and assure that the crew understands their message: Namely to proactively ask the simple question of: “What have you really understood?”

- **Organizing different teams into one force is a major leadership task;** Leaders use organizing principles to arrange the units at the work place according to the complexity of the tasks at hand. IMR projects are complex and need a variety of knowledge and skills in order to be performed successfully. This is solved by assigning different tasks to component teams having specialized competence, where each task could only be finalized with a concerted effort from several teams integrated into one action team under one supervising leader. One offshore manager said (Jonassen 2015):

> The total competence stays within the team; they know when mistakes are made and what they did. They don’t like leaders to interfere, which would only lead to less focus on doing a better job.

Conclusion

We have identified four foundations of leading a multiteam system: Practiced values (respect, trust and tolerance), openness, collaboration and a sense of belonging and mastering. As foundations of leading behavior, this facilitates the coordination of teams into one multiteam system leading to quality in planning and execution. A balance is instituted between creating a structure through a clear task plan, the introduction of everyone to that plan and the development of flexibility by organizing supplemental competence. Three dominating leadership behaviors have been described as:

1. Being able to create in the teammates a feeling of common identity
   Behavior were leaders display the purpose and the way ahead in a straight forward and simple way and
2. Finally, the behaviors of organizing the component teams to collaborate in a way were their different competences play together as a common force.

8. The Flow of an IMR Trip

In transit

When the vessel set sail for its two-week trip its 70 crew members became confined to a limited space and to one another, like a tightly knit family, for better and worse. Many shared a two-bed cabin alternating with a colleague working nights or days, respectively. The vessel could be described as a high-tech environment with state-of-the-art safety measures, comfortable living quarters, good food, and basic medical services. In the mess all officers and crew members ate together, although they tended to sit in groups along company or functional lines. We noticed that several crew members would knock on the door to the kitchen and thank the cooks for the meal when they had eaten.[21]

People worked twelve-hour shifts with no days off. Still, the work pressure was not constant. There was less activity nights than days, partly to limit the noise so that those off duty could sleep. The intensity of the work also varied with the stages of the operations, and between groups and roles. In addition to meals, some informal time was spent with others in the gym, playing data games together or watching TV, socializing on the spacious bridge (which included a sofa group) or in the 'dirty mess' (where people could take short breaks and take off their safety equipment, such as protective glasses, without cleaning up and changing into 'civilian' clothes).

21 This could be an indication that, for the duration of the trips, life on the vessel came close to what Ervin Goffman labelled 'total institutions', in which members share most aspects of life around the clock.

For many, time in transit afforded some slack that was put to use for training, maintenance, planning and developing work methods and solutions. For example, some ROV supervisors explained how their teams, that were on wait during transit, would spend time going over experiences from earlier operations and discussing ideas for improvement in their work methods. The same teams would also be responsible for checking and maintaining their most important tools, the ROVs, and would spend time in transit performing such tasks. On our field trip we also witnessed (and participated in) exercises for an emergency evacuation, fire drills and first aid courses.

Both captains and offshore managers underscored that it was necessary to help crew members switch gears from a relaxed 'vacation mode' to a more vigilant 'work mode' suited for the demanding operation off shore. In our material, several leaders reflect on how they sought to facilitate this transition. Organizationally as well as technologically the operations are complex. There are many organizational and inter-organizational interfaces that need to function well, with limited tolerance for misunderstandings and noise. Even before leaving port several 'familiarization' activities were put to use to get people acquainted and to provide enough shared information about the upcoming trip. Special care and attention was given to newcomers on the vessel (including the researcher), to make sure that they get to know their way around and get acquainted with emergency procedures and escape routes.

Very early on, just after leaving port, formal familiarization meetings were carried out in which nearly all newly mobilized people on board took part. The meetings, facilitated by the Offshore Manager and the medic had two overlapping purposes:

- To give participants an orientation on the goals, methods and schedule for the upcoming operations.
- To call attention to relevant health, safety and environmental (HSE) issues.

The Offshore Manager explained the goals of the upcoming operations, which in this case was to perform a scale squeeze on one well and to replace a subsea module at a different location. Although the meetings seemed relevant and useful, there were issues to them that several informants commented on in interviews. One concerned communication of operational information to a mixed audience. Some of those present for the briefings were not operational specialists. For the presenters the challenge was to communicate in ways that allowed all to grasp the essential information relevant to them. Some of the maritime informants expressed a wish to understand more of the operational issues. A second issue concerned the element of ritual in the safety information in the briefings. As always, specific issues within HSE of particular concern to the upcoming trip were addressed. In other cases, the HSE issues prioritized could form part of an ongoing campaign or focus within the companies involved in that period of time. These briefings were intended to promote collective mindfulness of safety concerns, and yet it was difficult for presenters or facilitators to keep the attention fresh because of the repetitive nature of such briefings.

Attention to safety was, however, a constant concern also outside formalized settings. In matters of safety, many mentioned a cross pressure between concerns for efficiency and concerns for safety but insisted that they would not bend to pressure and jeopardize safety. People like the client rep, the offshore manager and the medic had some freedom to prioritize how they spend their time even when the operation was in progress. In interviews, members of these roles were mindful of how they would use the slack to maintain contact with others on the vessel. An offshore manager described his leadership style as a variant of 'Management by Walking Around', and a client rep described how he tried to look for signs that crew members were happy and alert, since he thought this was an indicator of safe work practices. All the medics that we spoke with described examples of how they tried to put the slack in their roles to use to promote good HSE practices, or by being available as talking partners with colleagues that might need someone to talk to.

With representatives of all the contractual partners present on the vessel, people were literally in the same boat in terms of safety. Disagreements along the lines of the interests of the contractual partners did occur, over financial and technical matters. The parties did however tend to keep their cool and made use of a mechanism that helped them maintain the peace when at sea. If they noticed that they could not agree, they would agree to disagree by 'taking the matter ashore'. This practice involved documenting the differences of opinion and grievances and sending the issues to be resolved by their respective shore organizations. Leaders and people such as the medics also kept an eye on potential personal tensions, and in some instances of conflicts people were sent ashore rather than risk that tensions would escalate off shore.

A typical day in transit would involve a number of meetings. Each day there were morning meetings, and phone meetings for coordination and updates with the shore organization. Safety concerns were on the agenda of all the meetings that we observed.

Parts of the preparation of the operations were the dedicated Safe Job Analysis meetings with all parties that were involved in the upcoming operation(s). These meetings were normally facilitated by the project engineer. This practice involved developing and putting to use concrete Task Plans based on the original (and often more high level) planning on shore. These meetings, would review the feasibility of the plans and suggest improvements to them. We observed how discussions in the SJA meetings could lead the people off shore to push back on task plans from the shore which they saw as incomplete or incompatible with local conditions. Such objections often led to revisions. The project engineer was instrumental to revising the task plans and to create new ones if needed.

Approaching a destination

Most IMR operations take place in the near vicinity of oil rigs, and the vessel may need to enter the 500-meter safety zone around the rigs. The vessel needs to connect with the rig's own organization. The communication and interaction with the rigs are governed by Work Permits, and the responsibility for initiating contact is stipulated in procedures. Here we give a glimpse of a process that in reality is much more complex.

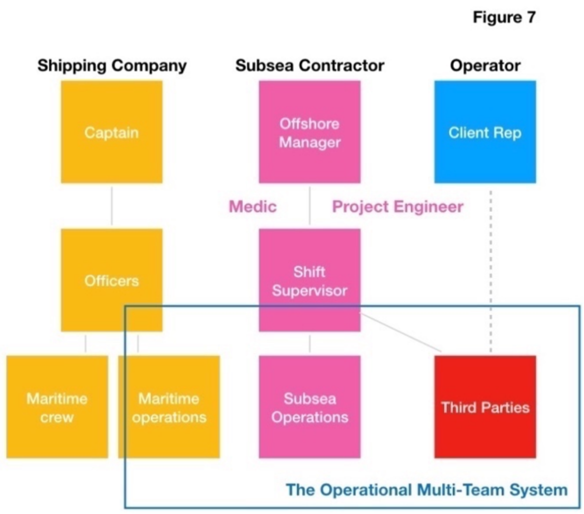
When approaching a rig, the captain on the vessel first communicated via e-mail to signal its arrival and requests permission to enter the safety zone. One hour before arrival the communication would switch to VHF. If the vessel needed to go up close and use cranes from the rig, communication would switch again to UHF. All radios are programmed for the same frequencies that Statoil uses.

Before arriving at a given location a safety briefing was carried out on how to evacuate the vessel if a critical situation should occur. If problems would arise during work on or near a well, and the well might need to be closed down, the client rep could send an order to the rig and make the well shut down within 15 seconds of confirmation. Once the vessel reached a destination the execution phase proper of an operation could begin. The vessel would then enter dynamic positioning (DP) mode to keep the vessel static over the location (without the use of anchors). This permitted the use of the robots (ROVs) that are 'flown' by pairs of pilots in their control room on the vessel. Entering DP mode within the 500 m safety zone, require a standard twenty minutes' operating safety procedure.

The operational multiteam system

At about the same time as the vessel went into DP mode, the organization also went through a striking temporary transition. The execution phase is complex (several parts interact in ways that are hard to predict) and tightly coupled (the interaction between the elements may sometimes happen so fast that ripple effects are hard to keep track of), features that Charles Perrow identified as risk factors.[22] These features are compensated by putting one role, the shift supervisor, temporarily in control over all relevant resources with a focus on task coordination (to some degree similar to crisis management in emergencies[23].) Parts of the organizations now form what has been described a 'multi-team system', indicated by the blue rectangle on Figure 7.

Figure 7: The Operational Multi-team System



The core of the system is the ROV pilots, here indicated by the pink box. The pilots navigate or 'fly' ROVs from their control room, where they sit in front of screens and operate the robots with joy sticks and other controls. Two pilots fly in tandem, one navigates and fly and the other operate the manipulators (working arms). At the vessel we studied on the field trip, two pairs often worked at the same time. One ROV is performing the actual task work on the template and the other support by supplying lighting and video recording. Each step of the way, their work is recorded on video. The recordings are use as proof of work and status at location. The

22 See Charles Perrow *Normal Accidents*.

23 A *contrast* to emergencies is that it is possible to put the operation on hold. The shift supervisor (and, in principle anyone who senses danger) can call an *'all stop'*, to win time for reorientation, should anything unexpected happen that threatens the operation, the vessel or the people.

pilots stand under the command of their ROV supervisor.

Photo 4: A pilot doing maintenance work on an ROV

But to carry out an operation, more individuals and groups are involved. The marine and operational crews on deck need to work together to operate cranes, and prepare tools, spare parts, and ROVs for launch. If the operation is a scale squeeze, pumps need to be manned by engineers and mechanics, and third-party teams and their leaders need to be drawn in to manage parts of the operation.

The work is coordinated by the shift supervisor. All operational resources, across organizations, companies and hierarchies are temporarily put under his control. While one shift supervisor described himself as a 'conductor' of the operation another described his role as follows:

> (…) the single point of contact for the operations, i.e., the ROV pilots, the survey department, the inspection guys, and the riggers who are on the back deck—so the people who are on the shop floor (if you like), carrying out the operation. I'm the guy who instructs each one of these people. If the client then wants something different or would like to have an ROV look at something differently, instead of the Client going directly to the ROV Supervisor and saying, "Can you go off there and have a look at this?" he'll speak with me. These guys on the shop floor get familiar with one voice and get familiar with the instructions of what's happening. They then know, if it's one single point of contact, that it's right and correct because that's the process.

The shift supervisor uses the task plan for each operation as his playbook. This defines the core priorities for his work. He is legally stuck in his control room for the duration of the operation (and two shift supervisors alternate if an operation goes on into the night). While other leaders do not abdicate during the execution of the operation, they mostly stay out of the way of the shift supervisor and others for this intense phase. At one end of a continuum are the decisions that are the shift supervisor's call, such as to take a second look at a subsea installation with an ROV before proceeding, or to call an 'all stop' if time is needed to understand an emerging situation. At the other end are decisions that have a strategic and contractual element to them, such as reshuffling a sequence of operations. In the latter case, the offshore manager may take the time to step back and have a conversation with the other two leading contractual partners on board, the captain and the client rep.

It goes with the territory of this way of organizing that the shift supervisor is almost solely focused on one leadership function, task coordination. The shift supervisor may need to stay somewhat myopic, since there is little time and attention left for issues outside the task plan under execution. We saw examples of how shift supervisors in the busy execution phase at times had trouble attending to other leadership functions, such as coaching and problem solving. The reliance on task plans helps execute operations to the degree that the flow can be predicted. But, when unexpected issues arise the procedures call for the development of a new and revised procedure (through a so-called Management of Change). Alongside this mechanism (with a somewhat slow response time) we found that more informal and improvised forms of response had developed that added flexibility to the ways the organization could deal with unexpected challenges in the midst of the busy execution phase. Occasionally, people not directly involved in the execution of the operation but with some spare time and relevant talent, would step in and help out in a situation that technically would fall under a shift supervisor's remit, but that he could not address without stopping the operation.[24]

To illustrate what kind of IMR operations may consist of, we take as examples the two operations carried out in our initial field work on the Edda Fauna.

24 An example: In an operation a client rep discovered that a technical problem would arise the following day, since the situation on a site was different from the assumptions underlying the task plan for that next day. He undertook to develop a new tool and to revise the task plan in time for the shift supervisor to make use of it. In the process, he emulated all the steps including the people to involve that the shift supervisor would have carried out had he had the time. See Johannessen, McArthur and Jonassen (2015) Informal leadership redundancy: Balancing structure and flexibility in subsea operations. Scandinavian Journal of Management 31 (409-423)

A scale squeeze

One of the operations to be executed on the trip was a *scale squeeze*. This is a procedure to clean clogged wells by means of injecting chemicals (mostly base oil) under high pressure. Each template, the steel frame that holds together each subsea installation, is connected to four wells, and, in this case, one needs cleaning. A scale squeeze involves the help of third party specialists, in this case from Halliburton. We noticed how the offshore manager urged the people on deck to get aligned on the task and how they would communicate in what became a very intense operational phase. As they were getting ready, a small gas leak from below was detected, and the operation was put on hold. By means of an ROV the cap of a valve was brought to the surface for inspection and repair. After some discussion that involved a second group of third party specialists (from FMC) the damaged filter in the valve cap was successfully replaced. Now, the cap could be brought down by an ROV. From the control room on board the shift supervisor and others could observe and control the operation, and images were shared on line with the adjacent oil rig. The relevant valve was opened with a torque tool and the cap was replaced, and the installation was ready for the scale squeeze.

The project engineer asked the shift supervisor to call a Safe Job Analysis (SJA) meeting, and the people involved gathered in the meeting room and the project engineer was taking the lead.

Photo 5: The 'Black eagle' ready for launch

To perform the scale squeeze, 'Black Eagle', a high-pressure hose needed to be lowered and steered onto the subsea installation. For safety, they agreed that most of the deck needed to be evacuated for people to stay clear of the hose. The hose had buoys attached at five-meter intervals, so that it would be easier to operate and to avoid sudden pulls. The hose will stretch horizontally in the sea like an S finally heading down to connect the template. In the process of attaching the floaters and lowering the hose through the moon pool, intense upward air pressure caused a foreman to lose his helmet several times[25]. Over a couple of intense hours, the well was injected with chemicals that would be left to work for about twenty hours. Two ROVs with two pairs of pilots were active during the whole operation, and everything was filmed and recorded. The pilots explain upcoming steps in the operation that is both listened to in real time by the others and also recorded to be part of the documentation.

We noticed very high engagement and intensity in discussions along the way. Even with the explicit emphasis on the importance of clear command lines, we observed a group of opinionated people who voiced strong views on the best way to proceed. Still the shift supervisor was clearly in control of the whole operation and the deck foreman calls the shots on deck.

A module replacement

While the scale squeeze was still in progress the project engineer led a new meeting to familiarize some of the key parties with the next operation, a module replacement. In this case people from FMC were the important third-party specialists. Maintenance work was to be done on a 'template' a structure on the sea bed near the wells where a number of modules are organized together on a steel frame. This allows tidy access to the relevant parts and makes it possible to repair or replace one part without disturbing the others. A so-called Subsea Control Module was due to be replaced. Put simply, this is the 'brain' of an installation and controls the opening and closing of valves, measurements of pressure and temperatures.

25 This was routinely documented and logged by means of a so called 'stop card', part of a system to document near misses and other unwanted events as well as positive feedback on anything people wish to comment.

Photo 6: Subsea Control Module

On this trip, the vessel also performed several other, minor operations, and also returned to the original site to complete the scale squeeze.

Demobilization

In transit back to base the crew prepared the next handover. End of job reports were written for each operation, and logs were kept for the next captain and crews to refer to. The vessel arrives back in base to demobilize equipment which is not relevant on the next, upcoming trip.

The operational crews that had been on duty for two weeks, just started on a four-week break. Half of the marine crews also change on each crew change. The marine crews that were signing off went on a four-week break after four weeks on duty. The new operational crews entered the vessel to engage in preparation and mobilization for the next cycle.

9. Subsea operations – past, present and future

An Interview with Sveinung Soma by Jan R. Jonassen

In this interview, Sveinung Soma, Project Director Norway at Deep Ocean, reflects on the past, looks to the future, and shares his thoughts about subsea operations in the light of opportunities and challenges arising from changes in the market, new constellations between companies, contracts, safety, and new technology.

Just to start, how would you say the cooperation structure between companies has developed in the past few years?

There has been no major change there, mostly they relate to an IMR-hub operator who is responsible for execution. Instead, we are seeing more that what typically before has been project assignments, and were suited for completion with an operating warm boat/organization, we now are developing more into complex/ larger assignments within IMR.

So, we have actually expanded the IMR term, instead of narrowing or decentralizing it. It feels like, at least Statoil, but also AK-BP and ENI are going in the same direction. They now, in a way, centralize what can be completed through IMR, and then assign an internal coordinator in their company to get it done.

We have had a change in the market since 2011. What would you say is the biggest challenge you are experiencing in relation to the market 2014-2017?

The biggest change is a total reduction of overall work. We think there are several reasons for this. Naturally, it revolves around the operators' need to reduce operating costs, due to the sharp reduction in the oil price after 2014, and we see as an effect that the work specifications are simplified. They have previously done more than they are strictly required to do according to government requirements. Now, we are closer to these minimum standards. We hear the term risk-based maintenance quite a lot now.

If you want to maintain your integrity but you do not need to maintain your production, you have a lot of your answer there. Before, if production at a well stopped it was chaos until they got it up and going again. That was when oil was at 100 dollars per barrel. Now they think, yes, the well is down but the integrity is still intact, we can wait and make maintenance and repair part of our next big campaign.

When you say integrity, do you mean the solidity of the technical installation?

Yes. If there is the possibility to continue with the error, without it worsening beyond the breaking point, to put it like that, they will let it be. That keeps occurring.

Are you seeing a tendency when the oil price rises towards 70 dollars and costs are going down, that it will start to affect maintenance?

That is possible. I think it is still too early to say. What we do have, or rather, what we saw last year was that the operators added more work to the ongoing campaign. This applies especially to operators who perform maintenance in time-limited campaigns. Because when they first start or have an ongoing campaign it is easier to build on the existing campaign. The vessel is there and they have everything they need to do it offshore, so why would they delay? It is easier to make the decision to do it now, rather than wait, probably.

But what happened along the way? They could have planned to do it in advance.

It looks like it is happening along the way. We have examples of this. During the winter, it is important for us to know what our customers' needs are. So, we can plan for the vessels' future needs regarding the various boats that are around. And when we initially have a contract, with a minimum amount of days that we are committed, the result often shows when we settle the bill at the end of the year that the time span can be many times more than the initial estimate.

We are seeing things are building up. It may be because their decision-making process is further down the road and the picture is not quite clear at the time, so they do not want to commit. The operators will hold back as long as they can. I think it is also because they are more resistant to spending. They need to do some further consideration to convince the organization that they actually need to spend money. This is both natural and understandable in light of the necessary cost savings due to lower oil prices.

But what are the consequences for planning and engineering when you need to make big changes in the middle of a campaign?

As a rule, there is a bit of flexibility and time for planning, so usually it is not a problem in relation to planning the individual job, both technically, but also concerning safety. We need to gain a larger perspective and look at the entire portfolio to see how we can maximize the

use of all the vessels. This is where our challenge lays relative to this.
If you relate, for example, to contracts with continuous vessel activity, this is happening all the time, but it is in a way within the framework, which gives us a perspective of one to two months. But within that period, things can be postponed making room for more urgent assignments. Then you need to readjust your plans. Nevertheless, we need continuously to balance all the time how close to mobilizing we can accept an assignment in order to plan a safe completion. It will always be like that.

Organizing for flexibility and effectiveness

How do you see long contracts contributing to stability and effectiveness?

Without a doubt, long contracts give the employer more predictability in how much capacity you can have in-house and how much you need to flex with contract employees. We strive, in any case, to use the same people again. You can ideally have 20% contract employees on a vessel, because it is the same people again and again, they don't just have Deep Ocean on their resumes. That assures continuity in our work and minimizes the risk within completion. It is clear that when you have long-term contracts, you can have a good base of people who are employed with you. Naturally if you have long term contracts, you also have long term contracts with the shipping companies. So, you know that you have vessels that you need to staff up.
You can also have some spot contracts, which we see has increased lately; more and more of shorter contracts. Naturally, if you already have a long obligation on a vessel, you will want to take advantage of that vessel. You cannot just man up and down on that vessel all the time without further hesitation. So, you should also have a good base of people that give you continuity.
But we see that the market has gotten bolder, and that the shipping companies are allowing more in these uncertain times. You can hire a vessel on what we call "pay as you go" agreements, so instead of having a 3/5/8-year contract with a shipping company on a vessel, we can give the shipping company a minimum commitment for x number of days per year. Beyond that, we have a pay as you go agreement. That means that when we have used the fixed quota of days in our obligation, and we do not have more work for the vessel, we can turn to the shipping company and ask them to release it from hire. When we eventually get a new job, we ask the shipping company to make the vessel available for us again and hire the vessel as long as the next job requires.

But the security lies in that there is a sort of core at the retaining regime, so it's a minimum contract?

Yes, then the shipping company knows that there is a minimum, so we have some security in that commitment. We know what we have to sell, in order to still take advantage of a flexible agreement.

But the shipping company can still lease the vessel to others?

No, you usually have a sort of "first right of refusal". If another company would like to use the vessel, the shipping company first asks us, and we can say yes or no to the request but then, if you refuse to rent the vessel to others, we must take it ourselves. We can't be unreasonable either. Clearly, if you have your whole fleet on such a contract yes, it is very flexible, but you also need to look a little at the flexibility of your offshore employees in the company.

Yes, because you are not sure if they can afford to wait for calls?

That’s right. At the same time, we see that new models are emerging in that area, too. Instead of going to arbitrary companies to hire your personnel from, you have 3-4 regulars that you use. But you know that this is expensive in the long run. In any case, you know that if you need to have a lot of contract workers, then I would look at a model with some form of vertical integration. You actually go in on the owner side of a staffing agency and have access to a pool of people. That would make it less expensive and you could keep some of the profits as well. You would then have a base of workers you can hire yourself, but who are also available for other market participants. So that’s one model. Things are happening there too.

Have you used that model?

No, but we are going to. It is something we are working on now with Level, it is still early days. IMR contracts on the Norwegian shelf are the most stable. Deep Ocean is the largest service provider within IMR on the Norwegian shelf, and we also we have the largest group of organized Norwegian offshore workers from the Safe Trade Union. We are definitively the largest provider on the Norwegian shelf. Some of our competitors are more exposed in the construction market and the construction market is much more internationalized.

Within some of the IMR contracts, the operators are required to have key personnel speaking one of the Scandinavian languages. By that we compete pretty much under the same conditions. You should have mostly Norwegians, it ensures continuity. So that is really good.

We see from our data that managers on board have some slack; some can spend their time more flexibly. For example, the rep and the medic could assume a supplementary role, even

though they are not formally a part of management. They can perform additional roles. We see that it could have implications for improvisation, possibilities for being more flexible and it could have an influence on efficiency and safety. Do you see these elements here?
Yes, because in a way, we have a reserve of competent people who are not a part of our production line. You have some that can see the whole picture in a slightly different way. They stand apart, and do not have a task they are working on right there and then. The offshore manager and usually also a client rep, who have a lot of experience from operations, represent a large reserve that you can tap into if you need to. The engineer too, some of the time, is not a part of the production line either.
The engineer is a little tied up, isn't he? He can start planning his next operation while they are executing the plan. So, he is focused on the future.
That's right. He is the one you can ask if you really need to, you know. You have a detailed task list, step by step. He normally knows the history behind the task list and the reasons for the different steps. So, he can come in and suggest if that doesn't work we can do this instead, because the result will be the same. I completely agree with that observation.

Real-time development

Do you see any changes here?
Not really. Maybe I can see some changes regarding the typical set up on IMR vessels; on a vessel where there could possibly be 70 men, lots of people are on deck and a third party is handling a Scale Squeeze. In addition, you have some personnel from a SPS supplier; FMC, for example, a team of 5 to 7 men. People on board jokingly call them 'tourists' since they, for long stretches of time on a 14-day trip, have no significant work assignments until their equipment is being put to use and then they become central to the execution of the operation. In the future, we will see integrated operations. They will likely run the operations from land via 4G transfer to the vessels, etc. So, it might be that one tries to reduce the number of 'tourists' on board, to use that term, because sometimes they are on board for 14 days, and they may only work 3 or 4 of them, as they support only one of the many operations. There is clearly a large cost associated with that.
So, if you can make one operation so robust that you don't need to have as many people out there or that you can actually transfer the work assignments to the personnel on deck through courses and training, you make it more cost efficient, but achieve the same goal and maintain safety.
Changes will occur more frequently with combined operations, also that they can actually be

operated remotely. We have tested running ROV from Simsea's simulation center in Haugesund, on the vessels that operate Statoil's IMR contract. Where ROV pilots on shore take over control and operate the ROVs from shore, we can start to think about reducing the number of people onboard. There will be things you need to resolve so that you will be equally focused on the assignments that happen as when you are all in the same room. But there is probably a lot of progress happening in that area in the future.

There is actually a requirement within IMR contracts that you should be able to do that. The vessels must be set up for that, and you should have facilities on shore to make it work. But this change will not happen overnight. Now there are 12 ROV operators on board to operate two working class ROVs. You don't just remove all or half of them. First, you want to know if it is sustainable to do so and then you might start thinking about it; what if you do it from shore? Then you need to redefine the job descriptions out there. They need to be competent in operating ROVs, but also in signal transfers and other areas. So, you must make small changes to make it work. It is something that is definitely coming.

And it is possible that when you are located close enough to an installation, they may have a fiber cable between the installation and shore. They have a local 4G that connects to us, which also goes through the fiber, because on the satellite you have a lot of latency, so called, delays. If you fly a ROV with too many delays, it will be too staccato.

When it comes to offshore manager (OM) positions, are they doing the same as before?

Yes, it is the same.

That role has not changed?

OM is the same, shift supervisor; all the roles that you have seen here are the same. Yes.

But what has changed with the way the assignments come together in the operation?

Let's look at the definition of an IMR vessel. "I" stands for inspection. It is often confused with the term survey, but we call it inspection. What we do on an IMR vessel is inspection of the typical structural elements.

We must distinguish that from pipeline inspection. When we do pipeline inspection, we do not do it in the same format as in the IMR setup, as you know it. Usually it is so demanding of the onboard system, that it is too specialized. What we do on an IMR vessel is more of a visual inspection. You can also say that we do a little ultrasound/x-ray and some different things, but you also go underneath and look at the underside of the platform. You look at the SPS equipment, record some video, and a little bit of this and that. How much of the cathodic protection is eroded? How is the condition otherwise? We can look at cracks and stuff like that. There are different tools on the ROV. That is typically, what one does on an IMR vessel

in relation to inspection.
And part of the development we see over the past ten years is that we have made it more efficient and integrated, so much so that when you, at the one moment change out a module, that you can turn around and start the inspection assignment. Before that, one would like to have clean inspection campaigns. This month we are doing an inspection campaign, next month it will be a module management and scale squeeze. We now see a change in having personnel and equipment, which can do both I and MR at the same time onboard, because then you get more flexibility in the usage of the vessel. So, if you are waiting close to a rig for something, it might be appropriate that you use the down time to supplement with an inspection.
So, it has become a bit more integrated and that integration actually consists of someone operating the ROV, with inspection qualifications and they have their own line of certification. This is called CSWIP, and it is a standard competence assurance certification that they issue in England. So, you have this certification for the pilot on the ROV documenting and watching everything he sees. In addition, you have the inspection manager, and the inspection manager is actually the one who in connection with the inspection, assumes the role of the shift supervisor. So, the shift supervisor has a combined role in the inspection and the ROV team has a combined inspection role. Yes, there is a bit of a change there.
There is a tendency developing towards higher complexity, a bit bigger and heavier things, which we are asked to manage for the customer. Now we are at the point where the battery packs are coming in for full force. You put the battery packs on board, around the size of 7-8 Teslas, not that you can run the vessel off the batteries, but it gives you a battery backup. It makes it possible to reduce the vessels' use of fossil fuels. Because when you get to a DP operation, instead of having to start another diesel motor you can handle the peak loads with the battery. And you can give some of the power back to the battery when doing a lifting operation, like a regenerating effect. If you break a load down on the way down, for example, during active heave compensation, you can charge like a dynamo supplying electricity to a battery, a power bank. Things like that are coming more and more. Not least the installed battery capacity will give the vessels more redundancy capacity in the light of DP class requirements. Where you otherwise would need to have the machines going to give redundancy on the available effect, with the battery you will have what they call a spinning reserve, like a battery bank with enough effect to draw from the battery to maintain the DP class.

So, there are quite a few changes in the technology available, but there hasn't really happened anything big since 2011, and until today. There has been a vacuum in the industry. Keep afloat; do not use too much money until you can be sure of a return on investment. I think there is going to be an upturn now.

The digitalization that happens around us in other contexts, in the private market or in other industries, electric cars etc., has had and will have a strong impact on subsea operations.

The future is technological and organizational change

What else do you see in the future? What do you see coming?

I can see big structural changes coming. We talked about being able to fly a ROV from land, and you can imagine drone technology coming. Instead of sitting in a chair with joysticks in front of you watching, you will soon be able to control the ROV like a drone with your telephone and VR glasses.

So, many things can come in here now. You can imagine more vertical integration can give others access to performing a service directly to the oil companies. So, things can turn around a little, especially when it comes to inspection. You probably do not need a large vessel. You put the ROV on the seabed with batteries and an antenna going up and then you can fly it from shore and inspect until the battery is discharged, or you can put it on a generator that runs on a marine current turbine.

There are also things related to remotely controlled vessels. We can already see the Yara Birkeland sailing in the Grenland area in Norway with cargo from A to B, where it is operated completely by remote control and partly autonomously, between two ports. We have Tresfjord up in Trondheim, which is the test fjord for autonomous and remotely controlled vessels. So, we have a situation where a good deal of resources is being moved around, on land for some of these operations - ROV etc. I think this change will continue. One can do more and more complex things remotely after one gains experience with it.

How will this influence you, as a company? Will it knock you out of the competition, hollow out your company or will it redefine your purpose?

It could possibly do both. I think most importantly we need to keep up, follow along with what is happening and understand the changes that are coming. Things may change quite dramatically, especially on inspection when the vessel supplier, or the subsea service provider in a way become less important, relative to the previous situation. We think that if you have a vessel with all the equipment and with personnel and therefore the whole spectrum of services in one place …. you may not really need that anymore, you will need a

lot less on the vessel permanently.
And with this arises the possibility that the others can enter the market. I think one can imagine that you need less capital to get in and complete an operation. You can buy a subsea drone for a fraction of what a ROV system costs. You ship it on a supply vessel, sit on land, and control it. That is the sort of things that can come.
We have also seen some joint ventures, or partnerships between operators and subsea companies. Subsea7 and AK-BP already have one on the installation side. You have FMC and Technip who joined forces. There have been things like that, which mean that the picture has changed. How you get in and what you compete against has changed both in terms of technology and business models.
Do you see a future where you would be standing alone and develop your own things? Or do you see possible partnerships with diversification?
Yes, we do. We are looking at such things; should we engage more in development of the technology, instead of being purely a user of it? That is something we are considering.
We neither develop nor build ROVs ourselves. We have purchased ROVs mostly from Kystdesign (a Norwegian designer and manufacturer). Vessels are usually hired through the shipping companies. The technology comes from other sources than us. So, it is clear that there are things we need to look at all the time. There can also be other things. Are there other technologies we must buy into, to get a step ahead of the rest of the market? Things like machine learning; object recognition, algorithms, etc., that make it possible to receive more information when flying directly and quickly over something. There are amazingly exciting things going on in the development front. Things are happening extremely fast now and are very exciting!
January 2018

10. References

Maritim Verdiskapningsbok 2014, Maritimt Forum, Oslo.

Bieder, C. and Bourrier, M. (2013) Trapping Safety into Rules. How desirable or Avoidable is Proceduralization? Farnham: Ashgate Publishing Ltd.

Johannessen, I. A., McArthur, P. and Jonassen, J. R. (2015) Informal leadership redundancy *Scandinavian Journal of Management* 31 (409-423).

Jonassen, J. R. (2015), Effects of multi-team leadership on collaboration and integration in subsea operations, published in International Journal of Leadership Studies, Regent University, vol. 9 Iss1, 2015. ISSN 1554-3145

Lindaas, J. C. (2013), Kompendium i undervannsteknologi, Høgskolen Stord Haugesund.

Weick, K. E. and Sutcliffe, K. M. (2007) *Managing the Unexpected,* Wiley, New Jersey, USA.