What is actually implied by integrated operations?

*Understanding the phenomenon and generic elements with a potential impact on the risk of system accidents.*

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This report was prepared in cooperation with the Petroleum Safety Authority (Norway) and the Center for Integrated Operations in the Petroleum Industry. The objective of the report is to describe a set of possible future IO solutions for different systemic levels. Moreover, the report aims to shed light on the potential impact of changes on human and organizational factors associated with these solutions in terms of the system accident hazard. Factors with a potential impact on the system accident hazard emerged as a result of elaboration of event scenarios based on experience and on assumptions about how such events may potentially develop. An identical report in Norwegian is published with report number SINTEF A7078.
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Preface

This report was prepared in cooperation with the Petroleum Safety Authority (Norway) and the Center for Integrated Operations in the Petroleum Industry. The objective of the report is to describe a set of possible future integrated operations solutions on different systems levels. Furthermore, the report aims to shed light on potential effects on the risk of system accidents caused by changes to human and organizational factors associated with these solutions. Factors with a potential impact on the risk of a system accident emerged through the elaboration of event scenarios on the basis of experience as well as assumptions about how such events may potentially develop. Interviews with key personnel involved in existing integrated operations solutions in the industry, as well as discussions during a workshop held on 14th August 2007 had a central place in this work. The final sections of this report point to human and organizational factors identified as relevant to risk assessment in integrated operations in connection with two or more of the described solutions/scenarios.

The description of solutions, scenarios, and generic risk factors in this report does not provide any authoritative answer as to whether integrated operations lead to an increased or decreased risk of a system accident. In addition to the elements described in our scenarios and generic factors, there will also exist other significant elements and other significant factors in terms of integrated operations risk management. Our selection of elements may, however, serve as a basis for further work in the field of developing and conducting consequence analyses, risk analyses, and risk management related to human and organizational factors associated with integrated operations.

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1 We have chosen to use the term "system accident" in order to emphasise that we look at accidents that not only involve damage to systems as a whole and that affect the system in such a way that it stops, but also involve the unanticipated interaction of multiple failures in which the accident emerges.
Introduction

This report presents a set of potential integrated operations solutions in the shape of scenarios and findings relating to the changes contained in these solutions compared to more traditional modes of operation.

Integrated operations solutions are discussed on three different levels:

1. System level: The operational philosophy/concept is based on integrated operations (operation of production installation).
2. Subsystem level: Central work processes or areas of activity are based on integrated operations.
3. Component level: Selected components are operated/supported somewhat more specifically by means of integrated operations (job design/tools operation).

By...

...component level we mean single components or single-component systems (turbines, pumps, safety systems etc.).

...subsystem level we mean for instance drilling and wells, production, operation and maintenance, modification etc.; i.e. not the entire operation, but its constituent parts.

...system level we mean systems in their entirety; i.e. total concepts such as remote operation, unmanned/automated production, the system of operator, supplier, authorities/inspectors etc.

A disaster is an event concentrated in time and space, which threatens a society or a relatively self-sufficient division of a society with major unwanted consequences as a result of the collapse of precautions which have hitherto been culturally accepted as adequate (Turner and Pidgeon, 1997).

System accidents or disasters are the accidents we remember and hear about for years after the event. They leave a mark in the shape of changes to regulations or work procedures; or in the shape of companies losing their reputation or substantial assets, or going bankrupt as a consequence of corporate fines, costly compensation payments or changes and such. System accidents often involve the loss of many lives, such as in the Alexander Kielland and Piper Alpha disasters. System accidents also include accidents with a great impact on society or the environment – such as the Longford disaster, which only claimed three lives but cut off Melbourne’s gas supply for two full weeks and thus created societal-level problems.

System accidents are more often than not systemic accidents, which in the oil industry involve complex and sometimes closely connected systems. They can therefore rarely be explained in terms of simple causal relations. The interaction between human, technological and organizational factors – i.e. the connections between the factors causing events – is not linear. Hence, the risk of system accidents cannot easily be assessed solely on the basis of traditional risk analyses, since “everything” (we measure) may seem normal before things explode. Complex, non-linear systems cannot easily be described in an exhaustive manner, and the interaction between the system’s components is typically dynamic and subject to variations. A central question is therefore whether systems are balanced or not. Such systems therefore require barriers that prevent incidents from developing when swings beyond the foreseen variations occur. Why, then, should we NOT just forget about the component level and the simple, linear connections in our thinking around system accidents? We can not disregard them as changes to linear causal connections may impact on the balance of the overall system.
Small strokes fell great oaks. Consequently, we need the birds-eye overview; but at the same time also the eagle-eye attention to detail. In this report we primarily take the latter perspective in the sense that we are looking for changes, minor and less so, which in isolation do not necessarily make a significant difference in one direction or another in terms of safety. On the basis of this close inspection we can then lift our gaze and consider the impact of these changes, when seen in context, on the full risk picture in terms of the system accident hazard.

The accident and solution scenarios were developed by the IO Center with the help of central informants from the industry. These scenarios were then discussed in a workshop held on the premises of the Petroleum Safety Authority on 14 August 2007. The workshop engaged selected representatives from the industry, from trade unions, the authorities, and research institutions in an effort to define more precisely what changes integrated operations bring about, in terms of significance from a system accident perspective. Particular emphasis was put on human and organizational factors.

Previous articles and reports on integrated operations and HSE have focussed primarily on the impact on ICT security and working conditions. This report is our contribution to widening the basis for assessing the consequences of introducing integrated operations, as we shed light on the system accident perspective as a four-part arena, using the workshop discussions as our starting point. Our emphasis is not on technological factors, but these are considered to the extent that they are significant in terms of good interaction between human factors, technology and organizational issues (MTO).
Future scenarios

The scenarios described below are meant as illustrations, and are therefore not necessarily exhaustive in their descriptions of staffing levels or other conditions.

**Future scenario 1: “Well control and lean staffing levels. Integrated-Operations-support from onshore operations centre”**

**Organization:** Lean staffing levels; remotely operated production part of the time (at night).

**Onshore/offshore:** The offshore central control room (CCR) has one staff member on duty day and night. One offshore process operator. The total number of offshore drilling crew is 12 people, employed by the drilling contractor. The operator’s own staff man the company’s onshore operations centre, plus one representative from the drilling contractor between 08.00 and 16.00 hours. The contractor’s onshore drilling operations centre is manned by the contractor’s employees between 08.00 and 24.00 hours. 24-hour telephone service operated Mondays-Fridays.

**Working hours, shift arrangements and rotation system:** Offshore: 12-hour shifts, 14 days offshore and 4 weeks at home. Onshore drilling operations centre: 08.00-16.00 hours and 16.00-24.00 hours. The personnel rotate between day/evening shifts every other week.

**Production:** Oil: 15,000 FOE barrels. Gas: 95,000 sm3. The maximum production is some 68,000 oil barrels per day. Water and gas are injected into the reservoir to increase the oil recovery.

**Situation:**

We are in the final phase of a drilling campaign which started in the summer of 2006. When the original contract for the drilling campaign expired, a two-year extension was granted due to unexpected drilling challenges encountered during the early phase delaying the work.

After its 2006 reconstruction the platform no longer depends on support vessels in order to carry out drilling operations. All drilling mud processing and pumping is now conducted on board the platform. Consequently, the deck has less space available space for storing equipment, which means that vessels holding drilling equipment must stand by. In the previous drilling phase drilling fluid was supplied by support vessels anchored by the installation, which meant extra capacity for drilling equipment storage and for living quarters.

The drilling contractor is a sole supplier of drilling services in the sense that all areas of responsibility, such as directional drilling, drilling fluids, cementing or logging during drilling, are covered by one contract, which was signed as early as 2004. This type of contract is called an ISD (Integrated Service Delivery) contract, and among its central elements were factors such as total planning, cross-trained personnel and moving tasks onshore. The objective of the cross-disciplinary training across different job categories is to ensure that personnel are trained to carry out tasks in addition to their own field of expertise, even across company boundaries. It has emerged lately that there is a good deal of discontent with the many of the new arrivals’ level of competence, and that there is concern that events may evolve because those on duty, whether offshore or onshore, will lack the resources to handle the situation.
After Hanssen retired last year there is nobody with offshore experience left at the remote drilling operations centre. The onshore operations centre has problems persuading the staff to rotate to offshore jobs after they have experienced working onshore, resulting in the disintegration of the factory competence.

The Petroleum Safety Authority concluded after an inspection conducted in 2007 that the organization was faced with challenges in relation to performance requirements, competence, and training in well integrity, among other things. The procedures related to leakage diagnosis/status were also insufficient.

The wells in this field are considered to belong among the so-called “villains”: wells drilled in the 1990s where surrounding factors such as cost reductions and downsizing of organizations are assumed to have had an impact on the drilling quality.

Event:
The time is 04.00 and the alarm goes off: there is a subsea gas leak on the ocean floor. Some wells have proven unstable during maintenance operations over the past 24 hours. There are fears in the organization that they might be facing a situation like the one experienced at “Snorre A”. The drilling staff are somewhat concerned as to whether they have adequate resources at hand, as the minimum of well injection chemicals kept on the platform is adapted to normal drilling needs.

The following is a description of what well control entails (adapted from research scientist Robert Drysdale):

“The drilling has the tasks of adjusting the mud flow rate, mud density and choke pressure to maintain pressure balance in the well while drilling, tripping and under completion operations. Under normal operations, the choke is not used and pressure in the well is regulated through adjustment of the flow rate, (can change quickly, but has only a small effect) or the mud weight (can adjust pressure much more, but takes time to take effect).

Gas influx can be discovered either through increased pit levels or mud flow out of the well when the mud pumps are turned off. When this happens, the first step is to determine the severity of the influx. This is performed by observing the pit levels and mud flow out closely over a period of time.

If influx is small enough, the driller can continue drilling, but order weight material to be added to the mud.

Slight larger influx and drilling must wait until the well is again under control. This will usually take several hours and can be accomplished by adding weight material to the mud and pumping faster. The time for mud to circulate down the drillstring and up the annulus is one to two hours. After a period of circulation, based on how severe the influx was, the well is re-checked – circulation is stopped and we check to see if mud is still coming out of the well.

A higher influx rate will require that the well be choked. This is done by closing the BOP = Blow Out Preventer, (looks like an inner tube) that is inflated with hydraulic oil to close off the area around the drillstring and force returning fluid through the choke manifold. The choke manifold has a series of valves (chokes) that can be partially closed. Mud flowing through the chokes will cause a pressure increase in the well and help to stop the influx while heavier mud in pumped into the well. With the choke system activated, the driller can regulated the well pressure through the pump rate as the pressure generated over the choke is dependent of the flow rate through the choke.
An additional aspect to well control is that one cannot just increased the annulus pressure and stop influx of gas. This is because too high pressure in the well is also a problem. Excessive pressure in the annulus can lead to fracturing the formation around the well thus leading to an uncontrolled loss of mud. Simultaneously handling influx at one point in the annulus and loss of mud at another point in the annulus is very difficult.

These operations are today “crew intensive” as several things need to be done more or less simultaneously and at several places on the rig.”
Future scenario 2: “Onshore CCR”.

Year: 2015. The field has been in operation since 1980 and has entered the tail production phase.

Type of field: Gas/Oil

Wells: 100

Living quarters: 36 beds

Organization: Lean staffing levels; remotely operated production part of the time (night); one manned installation, one un-manned installation and one installation on ocean floor.

Onshore CCR: Complete onshore CCR in Norway; three shifts with three operators in each shift. All control room functions rest with the onshore CCR.

Offshore CCR: Complete offshore control room; manned by one operator on 12-hour day shift. The offshore control room is closed during the night. There are four offshore process operators, one of whom is available to the onshore CCR at night. The offshore process operators work day and night shifts and are all cross-trained.

Working hours, shift arrangements and rotation system: Offshore: 12-hour dayshift; 14 days offshore followed by 4 weeks at home. Onshore: The CCR has three shifts, each lasting 8 hours. On-shore staff rotation every 9 months. The staff of the operations group and the planning group have standard 8-hour workdays.

The platform’s energy needs are supplied by onshore sources. There is an emergency generator on board for use in the event of power failure. Communication via satellite is also available as a backup in the event of the breakdown of ordinary lines of communication.

Situation:

The field has been in operation since 1980. According to studies, remote operation of the platform would improve both the efficiency and the safety of the platform; and furthermore extend the life of the field and the wells. For these and other reasons, a decision was made to move the CCR onshore, and the decision was implemented in 2012 – three years ago. Current technology made this scenario possible. Three operators man the CCR. A control room still exists on the platform: it is manned by one operator during daytime. An subsea installation is also operated by the CCR, via remote control.

Oil and gas fields on the Norwegian shelf are remotely operated by an onshore organization consisting of groups of experts within different areas. Some experts, located in Nigeria, have been hired to help interpret the steadily increasing amounts of reservoir data. The communication between the CCR and the hired expertise takes place in interaction rooms (broadband communication), and on a daily basis. These exchanges include consultation as needs arise in addition to scheduled, regular meetings, and meetings by appointment. The experts in Nigeria offer well-service support at night.

Due to the large numbers of offshore workers retiring in the period between 2009-2013 and recruitment problems in the years prior to this period, few people on the platform or in the CCR possess offshore experience of any duration. Recruitment problems at home is also the reason why a number of offshore engineers have been recruited from countries whose language and culture differ from that of the Norwegian workers.
There is also an onshore operations group, assisting the CCR and the platform in making the right decisions on the platform and ensuring continuity between shifts. A different onshore group takes care of long term as well as day-to-day planning. The CCR, planning group and operations group are co-located and grouped according to tasks, interaction needs and belonging.

Some of the challenges so far have concerned differences with regard to culture and language, different offshore/onshore shift arrangement, and the handling of an increasing number of handovers. The fact that they are under constant pressure from different directions to increase production has also represented a challenge for the control room operators.

*Defined situation of hazards and accidents (DSHA) (in Norwegian: Definert Fare og Ulykkesituasjon(DFU))*:

Power failure and fire
Maintenance work is being conducted on the platform for combined oil and gas extraction. A valve on pump A has not been adequately tightened by the day shift maintenance staff because this pump was supposed to remain inactive for the duration of the maintenance period. Information that the valve has not been tightened is not passed on to personnel arriving for the evening shift. In the course of the evening shift, a technical error occurs in pump B. Unaware of any problems with pump A, the operations management decide to start it up. The decision is made without conducting the required inspections beforehand. A few minutes later the low-level gas alarm is activated. The high-level gas alarm is activated another few minutes later. At the same an explosion occurs, followed by a fire causing power failure. The offshore-onshore communication channels are disabled.
**Future scenario 3: “Integrated supplier of crucial safety equipment”**

**Year:** 2012

**Type of field:** Gas

**Working hours, shift arrangements and rotation system:** CCR manned during daytime. Integrated supplier conducts 24/7 continuous technical monitoring of SIS/ESD.

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**Situation**

In 2008 the operating company, Hydroil, and the supplier, CDD, signed a contract concerning the administration of Safety Instrumented Systems (SIS) on all the installations of the Valemon field. Safety Instrumented Systems (SIS) typically implement autonomous functions critical to safety. One of the most important functions within SIS concerns automatic emergency shutdown (ESD). The confidence in the ESD function is expressed through Safety Integrity Level (SIL); cf. IEC 61508 and the PDS method concerning required SIL level and verification.

The ESD function at Valemon is classified as SIL3, reflecting the fact that errors have serious consequences, and that in practice there are no (safe) alternative ways of shutting down the installation in an emergency situation. Safety Integrity Level 3 implies a high level of implementation redundancy and safety, meaning that (early) signals of internal errors are not
easy to interpret without deep technological competence. A difficult strategic question for Hydroil is therefore to determine what technical competence can be isolated and what can be outsourced. In a short-term financial perspective, suppliers like CDD are becoming increasingly attractive to Hydroil.

The CCR at Valemon monitors the ESD alarm during the day, whereas the CCR function is transferred to an onshore operations centre at night. CDD conducts 24-hour continuous SIS monitoring with regard to technical integrity and system error. The connection between CDD and Hydroil goes through the Internet before it enters Hydroil’s internal computer network for administrative and technological matters. Security (for example hacking) is thus a crucial concern. Since both CDD and Hydroil were familiar with the SeSa Method developed in the PDS forum, this method was used to verify that such a connection would not (by design) undermine confidence (i.e. the defined SIL level) in the SIS. An (administratively speaking) important part of this set-up is that to a great extent, CDD’s SIS operations are controlled through a system of authorizations. However, neither the technical nor the administrative factors of the “SeSa criteria” have been subject to any systematic follow-up or renewed controls over the four years since the signing of the contract – despite the fact that changes/revisions have been made to many of the procedures – even the CDD user interface – several times in the course of this period.

On the technical side, a crucial premise for the SIL3 classification of the ESD is that other technical installations (process control, maintenance) do not undermine the independence of the SIS (Safety Integrated System) in general, and the ESD (emergency shutdown system) in particular. Given the large number of suppliers performing different types of modifications and maintenance, and the fact that from time to time, they are (temporarily) forced to override ESD functions, this point represents quite a challenge.

The implications occurring over time due to the fact that those in charge of the ESD system are not physically present – some of them have actually never been offshore! – represent yet another factor (not dealt with in the SeSa methodology). Moreover, CDD’s technological administration is a 24-hour responsibility, but during eight of these hours this work is conducted from premises in India. The handing over of a good grasp of the situation is a particularly crucial factor. In practice, this depends on the existence of a system which covers all the vital parameters; on these parameters being understood in the “correct” way at any given time; and on no latent factors aggravating or being overlooked over time.

ESD/SIS technology and installation are subject to constant change/modifications. Hydroil and CDD are not always equally consistent when it comes to updating human/organisational factors accordingly. Furthermore, human-factor-oriented researchers have objected that this type of solution and the prevailing practice of regarding ESD/SIS as a “sum” of technical and human elements invite the classical misunderstanding of gravely underestimating the interaction between these. By treating the human and technical factors as independent elements that can be substituted and replaced irrespective of each other, the organisation is preparing the ground for dangerous situations in the future, according to the critics. This kind of practice invites contingencies, they claim, particularly under exceptional conditions.

The Valemon Field consists of a main platform at the centre, surrounded by several satellites of different kinds. Although many of them have independent ESD functions, these satellites all sort under the central SIS system of the main platform. The main platform’s CCR is manned during daytime, and has access to and receives alarms from the SIS/ESD. In practice, however, the technical administration of the SIS is conducted by CDD. The production requirements for the Valemon Field are high and on the increase, not least because it supplies
a new gas pipeline to Europe. Valemon’s SIS is therefore connected to a Pipeline Protection System, meaning that an emergency shutdown at Valemon will automatically lead to the emergency shutdown of other units along the same pipeline, and vice versa. These other units have similar SIS/ESD systems, but are operated by other suppliers, although in the same manner.

Many people at Hydroil are of the opinion that the margins have been under a certain pressure lately with regard to production regularity and volumes versus safety. The operating company has declared in a press release that the sale of gas to Europe will be increased by 10 per cent in the next six months, and on the installation people are aware that they will be supplying a large share of that increase in volume.

Incident:

December 2012 is an unusually cold one in Europe. Political relations with Eastern Europe are also rather cool, and gas deliveries from this region are hampered by more or less random operational problems, creating great problems for industry and for people in general. The price of gas is unusually high, and deliveries from the North Sea are crucial.

On a stormy night in the North Sea the SIS operator on duty in India is notified that the SIS has lost contact with some of the ESD functions connected to Valemon satellites. These functions are autonomous and may (should) still be working, but they can no longer be controlled. This introduces a dual uncertainty: will they work if necessary, or will they “kick in” unnecessarily? This means that in theory, the “isolated” functions may shut down the entire pipeline to which the Valemon field installations are connected.

At the same time Hydroil finds that it has a problem with the Internet due to a hacker attack on its internal network. The administration of the network, the firewall, the IT equipment, access codes, and so on is a virtual minefield – Hydroil has experienced and is still experiencing great challenges in this area. Whether Hydroil has sufficient competence to handle such attacks has been a topic of discussion for some (too long a) time, and no clear strategy exists as to how to go about this. Does the hacker attack mean that Valemon and other platforms should be shut down as a preventative measure?

CDD’s operator is not aware that a hacker attack has been uncovered at Hydroil, and that this is why he is unable to establish a connection through to the function/person at Hydroil who would normally give him the authorization to go ahead with regard to the SIS.

CDD’s attempts at establishing network contact (from India) with Hydroil fail, and eventually resort to a phone call. This roundabout approach is not routine procedure. Procedure allows for the possibility of immediately shutting down the autonomous part before it has the opportunity to affect the installation. However, this has never been done before, and CDD’s operator has second thoughts because of the great consequences involved (the energy situation in Europe is a well-known fact in India too).

After a couple of hours, CDD’s operator manages to establish contact (via telephone) with a Hydroil line manager, and suggests that production be reduced and Valemon sub-systems be shut down, based on a precautionary principle embedded in the safety philosophy of the company, and on actual existing procedures. The line manager sees the goal conflict but has serious doubts: should he reduce pipeline capacity, or risk a full stop brought on by an “isolated” ESD? The very idea that the ESD may represent a “loose cannon” seems so far-fetched that he decides to make no intervention. The line manager’s argument is that he finds it difficult to use hypothetical lines of reasoning as to what might go wrong produced by someone on the other side of the globe as input for making his decision.
However, neither CDD’s operator nor the Hydroil line manager are aware that a supplier of well-control equipment is about to discover that some of the equipment they installed at Valemon last week has a serious technical weakness that could potentially cause a collapse of data communication (in the vicinity of the ESD), and that it may also be infected by a virus from a software subcontractor. The CDD ESD operator for his part is experiencing additional stress due to the fact that the interface has recently been “improved”, so that he cannot find the monitor images he is familiar with – under “normal” circumstances. This causes him to overlook a new routine introduced for this type of (rare) situation – a routine which might have given him a chance to re-establish communication/contact with the SIS/ESD, and thus to clarify the initial uncertainty related to the SIS/ESD.
Generic findings

After the group exercises, the three groups presented their findings in plenary sessions. In this report we have sought to extract the essence of these findings in order to arrive at what we believe may amount to generic elements or factors distinguishing integrated operations from other modes of operation. This can also be described as what constitutes the changes brought about by the transition to integrated operations. The following points emerged more clearly in some of the scenario descriptions than in others, but according to our interpretation the fact that they apply to more than one scenario means that they qualify as generic.

There are great variations between the different factors focussed on here in terms of their potential impact on the risk of a system accident; whether their consequences will emerge in the short or the long term; and to what extent it is possible to implement measures in order to reduce any unwanted consequences of the change. These are not among the factors we discuss in this report. It is important that questions relating to such issues as how real and how great the risk is, whether it is accepted or not, and what possible measures might amount to are addressed by further research, development work and other initiatives within the industry and on the part of the authorities.

Boundaries, relations and distribution of responsibilities between operators, and subcontractors

In going through the scenarios, ambiguities emerged with respect to the planned design for boundaries between different groups, companies, licensed parties etc., and how these boundaries are meant to be practised. Such ambiguities become evident when contingency situations occur in one form or another.

Decisions can be made remotely, but how wise would this be?

New and more advanced information and communication technologies (ICTs) render possible the sharing of information and the forming of global organisations. Hence it is possible not only to have sequential/serial delivery of information, but also real-time data transmission and consequently the basis for making informed decisions from anywhere. Moreover, the actual decisions can be made from any location, but how wise would this be? Concern emerged during the workshop that efficiency and cost reductions are the driving forces behind many contracts. In such contexts it is all too easy to opt for solutions that fail to consider, for example, the decision makers’ qualifications for being familiar with systems in their entirety rather than only with their constituent parts. Even if planned information is shared and transferred in real-time, this does not necessarily mean that the same applies to informal and unplanned information. Such additional information may seem insubstantial there and then, but can contribute towards completing the picture in terms of understanding an occurrence. Although codified information in ICT systems travels fast, this is not necessarily the case when it comes to sublime or underlying information. Underlying information may, for example, be the concern that everything may not be working the way it is supposed to, when this concern does not feel “important enough” to warrant sounding a warning through a network. In a conversation between colleagues this “concern” might be mentioned, and thus contribute towards creating a different understanding within the group. Not all information seems crucial to safety when given, even if it becomes so in a later situation. The review of all the scenarios clearly demonstrates that suppliers’ and subcontractors’ relations to what can be
described as new or substantially altered safety and security barriers in connection with integrated operations are ambiguous.

*Integrated suppliers and contractual conditions*

The purpose of using an integrated supplier is, among other things, to maximize expertise and to reduce costs associated with the supplier and the operator/oil company having parallel organizations. This requires long-term contracts. It is commonly accepted that maintenance represents a difficult factor in such contracts due to the fact that since the supplier’s profit margin is small, he takes special care to protect it. Consequently, maintaining the right level of competence and training can be difficult unless such challenges are taken into account – and the common practice is to leave them out. Integrated contracts result in reduced manpower levels on the installations, and also make suppliers more vulnerable to changing markets and labour turnover. Another question is whether adequate resources are available in the organizations of the participants to take part in planning and implementation of change processes while at the same time maintaining safe operations. Challenges also exist in terms of identifying who is responsible when nonconformity and incidents occur during operations, such as unforeseen events related to the reservoir.

*Onshore/offshore boundaries, relations and distribution of responsibilities*

*Integrated operations lead to closer onshore/offshore relations*

IO can create competence, cooperation and close relations between groups that have previously not met or had any contact with each other. This seems to apply particularly within the same organization, while it is less certain how things would develop across different organizations. Going through planned tasks together with the help of ICT has beneficial implications. When people meet frequently the threshold for contacting each other is lowered, and there is reason to assume that this also applies to a certain extent when people have met through video conferencing or similar venues. If roles, responsibilities, functions and tasks are clarified and organised in the right way in such contexts, it means that many of the factors which form the basis for good handling of both normal operations and non-conformance situations – indeed even crisis situations – are in place.

*Who takes responsibility for saying that a situation is moving from “yellow” to “red” in terms of the condition of the installation?*

Traditionally, the platform manager’s role in assessing the gravity of situations has been unquestioned. With increased onshore involvement and control the lines of responsibility become less clear and who has the right to assess gravity less obvious. Disagreement followed by loss of valuable time may be one of the consequences. Increased pressures to improve production volumes and regularity may also contribute to the creation of such conflicts.

The onshore and offshore social contexts represent different realities in the sense that the installations constitute a more isolated social environment, whereas the onshore environment represents a normal situation given the social context is. This implies that the uncertain factors/risk factors cannot be controlled to the same extent. The actual risks faced by the different groups also differ substantially. Achieving the same degree of risk awareness offshore and onshore is a challenging task.
When several onshore centres (drilling centre, operator’s operations centre, and others) are involved, there is an increased risk of ambiguities concerning who defines the boundaries of what represents a hazard. The distribution of responsibilities for how a situation should be handled in order to regain control seemed unclear during the work with the scenarios.

**New communication technology – how good is it in an emergency?**

The richness of video conferencing communication has been questioned. It depends on the technology and on whether the technology and the environment/facilities are adapted to the purpose. We know little about how much of the implicit information is lost, for example through the use of videoconferencing for meetings that were previously conducted face to face (planning meetings, other meetings that were earlier pure offshore meetings). This finding relates to the paragraph above in terms of differences in risk awareness depending on the environment one is in, and in what ways videoconferencing can contribute – or not – towards achieving shared risk awareness among participants who are geographically separated.

In scenario 2 no risk analysis has been conducted concerning the impact of a loss of onshore-offshore communication in an integrated operations setting on the handling of the hazardous/potential emergency situation. The lack a plan for this eventuality generates great insecurity in scenario 2, onshore CCR. Questions arise as to what is lost when the CCR does not receive real-time information, but must nevertheless handle a potential emergency situation.

Integrated operations imply that a greater share of the control of the technical systems of the installations is based on “open” network solutions. Consequently, hacking and computer network break-ins pose a greater risk, and doubts may arise more easily in non-conformance situations as to whether the detected system errors are caused by such acts, or whether they are signs of real system destabilisation. Both far from the centre of a network and close to the actual operation distinguishing between the two can be a difficult task. It is unlikely that those actually present in operating rooms or in other ways connected to systems operation have the competence to distinguish between reasons why there appears to be user interface non-conformance. Measures that are initiated may hence be based on the wrong premises and thus contribute towards the situation taking a turn for the worse. Parallel to the implementation of integrated operations, the oil industry as a whole needs to improve its competence, awareness and understanding of information security (confidentiality, integrity, availability). It is perceived as a serious risk that ICT systems failure is not part of standard analyses of dangerous and emergency situations (Norwegian: DFU). In integrated operations-situations involving loss of communication or other ICT-related scenarios are relevant in relation to the definition of factors which can cause dangerous or emergency situations (DFU). They should be included in the definition in order to ensure that they become part of risk analyses, education, training and so on.

*Cultural and process-oriented challenges associated with global networks and “follow the sun” principles*
In cases where labour resources are in principle available “all over the world”, the long-distance workers often work at a time of day during which onshore workers in Norway are not at work. Hence those who monitor systems during those hours do not always have direct access to the network of experts and persons with the competence to help them understand system non-conformance. Whether the problem is still understood and a solution found will depend on the contents of the contract and the distribution of formal responsibilities, on cultural aspects, and on the experienced time pressure and regularity demands.

The contract may define more narrow limits for the long-distance participants’ roles, and ensure that they only have access to the “need-to-know” information that enables them to perform the tasks associated with their limited areas of responsibility. They will nonetheless inevitably be faced with situations that have not been planned for, and which do not come under their partially defined responsibilities; and defining what constitutes “need-to-know” information is equally difficult.

**Changes to shift systems, working hour arrangements and meeting arenas**

*Working hour arrangements and shift issues are unresolved tasks.*

Changes to shift arrangements and working hours both onshore and offshore may lead to turbulence in the organisation and cause potential lapses of attention regarding current activities and operations. The interfaces are many and developments seem to be going in the direction of more, and more complicated, handover situations. ICT, operations and interaction rooms make it possible to conduct handovers involving geographically separated participants, but great discipline and an even greater degree of planning are required in order to ensure that everyone who should participate in these meetings actually does so. The handover situation is a critical activity with a strong impact on the situation awareness among those participating in the operation. Inadequate handover resulting in incorrect situation awareness has been the cause of system accidents in the past.

*Are we facing a shift in the day-to-day approach to risks?*

Offshore planning meetings where all disciplines are represented have functioned as a place where people “look each other in the eye” and share information about planned and ongoing activities. If no risk elements emerge at the meeting, everything is considered to be adequate in terms of safety. This is an important arena. Such an approach to the assessment of overall safety is possible in systems with clear boundaries, a good overview of activities and whom they involve, and transparent technological processes. In complicated systems with many participants, where the boundaries between who is involved in the work and who is not are more ambiguous and the participants are numerous, an a priori understanding that “unless checked off as satisfactory, everything is assumed to be going wrong” is more common. This often implies the use of checklists as a normal part of all operations, such as in aviation. The work with the scenarios identified increased complexity in terms of who performs activities during daily operations, and increased distances between team members also increased the uncertainty as to whether one possesses an adequate overview of the risk picture. The arena for the evening planning meetings disappears or its parameters change.

*Increased automation challenges the situation awareness*
Increased automation is part of the ongoing development within integrated operations and is also seen as a critical factor in making possible scenarios such as the onshore controlling of offshore operations. Increased automation will also to some degree lead to the possibility of tasks being performed without the intervention of an operator. However, automation will also be an important tool in operator-controlled processes, where more complex operator support systems are based on various automation functions. Consequently, the human capacity for situation awareness faces a dual challenge: 1) the everyday work tasks will to a great extent take on the character of monitoring and less of intervention – leading to greater demands on the operator during non-conformance situations; 2) more complex information interfaces increases the mental demands of the work requiring greater expertise among the operators. The human capacity to regain control over unforeseen situations depends on the person involved having a correct perception of the process, the system, its status and the consequences of potential actions performed on the system. In addition, the person involved must also have the ability to operate the system and feel confident that he or she can cope. Confidence in one’s ability to perform a task is closely connected to experience and practice in actually operating the system.

**Virtual handling of major non-conformance situations**

*Adequate manpower levels for normal operations are not necessarily adequate during emergency preparedness situations.*

Organisations with minimum offshore manpower levels, or with only few offshore personnel on duty, may be faced with a challenge when trying to find enough manpower to run an emergency preparedness organization. One of the requirements applying to members of an emergency preparedness organization is that they must know and practise their role and participate in drills so that they are able to take responsibility in situations where guests or less experienced workers/service personnel need help, for instance during evacuation. This requires that the installation’s personnel are relatively permanent. The way things work today may turn out to represent a challenge since those who are on board may have only very limited experience with the specific installation and thus be fairly unprepared in terms of mastering an emergency preparedness situation beyond following orders. Also, the onshore/offshore redistribution of functions has not been followed up with any changes regarding who is supposed to take the lead or the initiative in such a situation.

*Integrated operations-related dangerous and emergency situations are not practised.*

As described under the point “New communication technology – how good is it in an emergency?” the existing definition of “dangerous and emergency situations” has not been adapted to the development of integrated operations, and integrated operations-related dangerous situations can therefore not be expected to be included in the emergency preparedness training/exercises. An update of the dangerous and emergency situation scenarios must also include the new groups of participants and systems that are part of virtual organizational structures.

*A small and transparent organization does not always have the opportunity to build redundancy and problem-solving ability*

The advantage of having fewer staff offshore is that it helps towards achieving a transparent organization in which it is easy to pinpoint where competence is present and where this is missing, so that the latter can be compensated for either through the switching of jobs/tasks,
or through the upgrading of skills. A focus on good barriers and robust organizations is important in relation to handling contingencies. Our participants questioned whether an organisation with few, but still permanent offshore staff, has the capacity to build the expertise needed in order to handle critical situations in a robust and error-tolerant manner.

**The validity of regulations and analytical tools – renewal of “use-by-date”?**

Regulations and analytical tools are based on existing organizational structures and working conditions, and are traditionally developed against a background of changes having occurred or research showing that changes are needed. To date, integrated operations have not had any impact worth mentioning on regulations or analytical tools. It is thus conceivable that organizational and technical integrated operations-solutions like the ones presented in our scenarios would be considered adequate under today’s regulations, without sufficient prior risk assessment of essential factors of the kind shown in this report. Questions were also raised as to whether existing analytical tools such as Quantitative Risk Assessment (QRA) will be adequate in terms of capturing different aspects of the risks associated with system oriented integrated operations.

**The change process per se – a safe or unsafe period?**

During the work of going through the scenarios it was pointed out that the situations and organizations described seemed to be the result of bad change management during the process leading up to the new solutions. Many companies do not regard integrated operations as a process of organizational development. Moreover, we have little knowledge in terms of what type of change management is significant during the development of integrated operations.

Today’s offshore work is popular because of the extra perks accompanying such jobs. Both working hour arrangements and compensation systems are expected to change when functions/tasks are moved ashore.

Change processes tied to the introduction of integrated operations represent a great challenge per se and may as such influence the risk picture. The implementation of change processes is a demanding undertaking given today’s organizational structures and shift arrangements. When the operational organizations become more virtual and include several different types of shift arrangements, the work of planning and implementing changes also becomes more complex. This will probably apply both to large-scale changes (change processes) and to smaller, reversible changes (operational adaptations).

**Conclusion**

In the introduction we suggested that system accidents should be regarded as systemic accidents, which in the petroleum industry occur in complex and sometimes closely interconnected systems. In this report we have pointed to factors which change the composition of the complex system, and we have pointed to factors which suggests that parts of the system may become more closely linked or that barriers may change, disintegrate or not be inserted in the right place when new connections are established. Furthermore, the complexity of the petroleum system increases with integrated operations, as this approach brings more participants into networks, decision loops and information interpretation.
We have demonstrated that there are important connections between integrated operations-related changes and the potential risk of a system accident occurring. For the most part, we currently lack adequate knowledge about these connections. Some of this knowledge will need to be generated through generic knowledge development (research), whereas some of it will have to be gained through practical experience and assessments made in individual enterprises. In this process it is important that knowledge generated in individual enterprises is shared openly in forums where people can learn from each other’s experiences. Moreover, we see that the same changes mean that it will become easier to share HSE knowledge between companies, thus improving the overall awareness of what is implied by risk and HSE – given that an active effort is made to achieve this. Integrated operations create an arena for such work and make it possible to conduct research and development work within this area.

We have not demonstrated whether the risk of system accidents increases or decreases with an integrated operations approach. But by adding a focus on HSE and system accident risk to the parallel development efforts within integrated operations we contribute towards making it easier to know in advance where we are heading.