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Capability Development With Remote Drilling Operations

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Abstract

Improved capabilities for real-time data transfer have given rise to remote monitoring and support for drilling operations, providing faster access to information onshore, reducing personnel on board (POB) and cost. The challenge lays not so much with the technical feasibility but with the impact on work processes, which is still poorly understood. This study investigated the human factors implication for Onshore Operation Centres (OOCs) in four centres in Norway and the UK, which all successfully delivered wells but addressed different strategic aims.

The sample comprised 25 semi-structured interviews, observations over three months and a longitudinal attitude study with 33 participants. Results were content-analysed by a team of industrial psychologists. The findings show that remote operations in drilling produce similar effects as virtual teams and computer-mediated process control in other industries; the monitoring work in the OOC was deprived of some of the physical activity, sensory information and informal interaction. Potentially some of these tasks could be further automated while more cross-trained staff would be required offshore. Different user groups responded differently to the OOC implementation. Onshore teams generally approved of the concept as the OOC helped to create more situation awareness and present an ideal environment for collaborative decision making and learning. The offshore response was mixed, with both strong support for its innovative potential and critical voices about system reliability, contractual concerns and the impact on work-life balance.

OOCs can add value to drilling operations by enabling better-informed decisions but the findings showed that success depends on how well the introduction of organisational change is managed. The study provides evidence how prospective users can be involved in the change process in this dispersed and fluctuating industry and which social and cognitive skills are important for effective collaboration in e-operations.

Introduction

The possibility to remotely monitor drilling operations via real-time data transfer is attractive to companies, as it enables them to manage wells in locations that are difficult to access or need special support. If part of the offshore team can be relocated onshore to support operations from an Onshore Operations Centre, fewer people are required to work in higher-risk environments offshore, thereby reducing the potential harm to people [1]. OOCs not only provide instant visual access to what is happening on the rig, they make it easier to call in additional onshore expertise to make better decisions faster [2, 3]. Once the full potential of global connectivity is realised, experts could observe and support wells anywhere in the world and Centres in North America, Europe and Australasia could hand over monitoring duties around the clock, thereby reducing the need for night shifts while still maintaining 24/7 support. A key requirement for this type of global interconnectivity is some degree of standardisation of IT structure and data format to enable easy, unhindered exchange of information e.g. WITSML [4].

Companies also aim at standardised solutions for the design and set-up of OOCs in order to make training, maintenance and upgrades easier to manage. Despite the obvious benefits to be gained from standardisation, there are a number of issues to be considered during planning and implementation of OOCs that may not be amenable to this approach. The ideal of standardised systems assumes a clean slate on which this standardisation can be achieved without eradicating existing technical solutions and local practices. From our experience this is hardly ever the case, as any drilling project must adjust to the local conditions and infrastructure.

Human factors perspective

From a human factors perspective there may be good reasons for local adaptations. The benefits of compatibility and consistency at company level do not necessarily translate into end-user benefits and may not suit the skills and needs of the actual user group. A local solution also makes it easier to involve users in the development of an OOC, which is the single most successful strategy to obtain credibility and usability [5]. Research on implementation of new technology

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has shown that it typically takes longer than anticipated and is less predictable than many people think [6, 7]. Often those parties who fear they will lose power, status or their jobs are those that are most likely to resist the changes. These problems can be mitigated by involving those that are likely to be affected, in the scoping and rollout of the changes and by providing a strong and clear vision of why the changes are necessary and how they are going to lead to a better future.

The early trials of Onshore Operations Centres in the 1980s faced technical difficulties as well as acceptability problems including sabotage, and some eventually had to be abandoned [8]. Since then, the concept of remote operations has become a lot more widespread and accepted. Various names have been used to describe these centres since the early eighties: Drilling Command and Control System (DDC)[8], Drilling Data Centre (DDC)[9], Operations Service Centre (OSC)[10, 11], Onshore Drilling Centre (ODC)[2], Onshore Operations Centre (OOC)[10, 12], Real Time Operations Centre (RTOC)[3], Technology Enhanced Ameriven Drilling (TEAMS) [10] and Advanced Collaborative Environment (ACE)[13]. Over time, the names reflect a gradual shift in emphasis from technology, activity or discipline to collaboration, recognising the importance of human factors in their use.

The time is ripe to share good practices and explore whether there can be standard solutions for certain types of remote support. Yet each drilling project will present different requirements, and the local cultures will also differ in terms of their receptiveness for remote operations. A higher awareness of human factors can ease this implementation process.

OOCs in UK and Norway

This paper reports research conducted between January 2004 and July 2005 in collaboration between BP and Aberdeen University. The aim was to further investigate the human factor implications for remote operations [14] and to study and support the introduction of a pilot Onshore Operation Centre for two wells drilled on the Andrew platform in 2005 as a UK pilot project [12]. Throughout this paper we will use quotations from interviews to illustrate our findings. Notably these statements represent the views of individuals, not those of the companies involved.

The first stage of the research compared existing OOCs in Norway and gathered evidence on the impact of remote operations from other industries. The literature, as well as our interviewees, reported the added value of OOCs as a collaborative environment for better-informed decision making and sharing of expertise. Both sources attest that the potential savings by far exceeded the initial investment. However, they also described negative effects for those people actually working in the OOC and highlighted the importance of careful planning.

Another important finding was the diversity of concepts and approaches to remote operations, depending on the strategic aim they were designed to support.

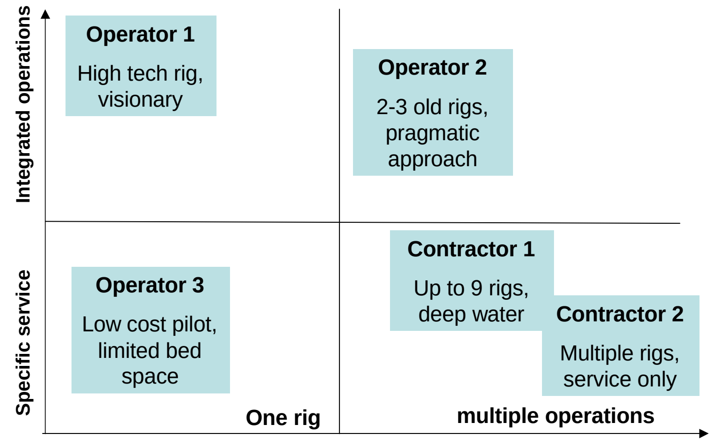

Fig.1 Different approaches to OOC design

Fig. 1 provides an overview of those centres included in the first study, organised according to number of drilling operations and the approach to integration of support services. Some centres have been designed as collaboration rooms to facilitate integrated operations and the sharing of expertise across disciplines. They typically support only one rig and the onshore team is located in adjacent offices. Interviewees explained that the intention was to create more ownership and to generate more involvement with the drilling project. The idea was that “a new breed of people” was needed who would proactively take an interest in what happened. As a result of this, the change at Operator 1 was not mainly related to the implementation of new technology but more to introducing team-oriented work practices.

The contractor-based centres support several drilling operations simultaneously and focus on providing specialist service. This approach can potentially provide expertise and learning across different wells and staff can be allocated more efficiently to rigs requiring attention during critical stages. However, it is psychologically unlikely that staff in a call centre style situation will develop the same sense of ownership and responsibility that Operator 1 aspired to with their integrated operations approach.

Fig.2 Meeting room before it was redesigned as the Andrew OOC

For the Andrew project, the main driver for an OOC was to reduce the required bed space on the rig, to accommodate the drilling as well as the normal maintenance crew without reducing the quality of support for the two wells. Unlike the other purpose-built OOCs, little emphasis was placed on collaboration and integrated operations. By using an existing meeting room the Andrew OOC was constructed at a fraction of the cost of the other centres, **Figs. 1 and 2**. The bed space limitation was also readily accepted as a motivation for an OOC by all team members, including the offshore crews:

"It was considered to be a must-do to make the Andrew Low Cost Drilling project fly".

The promise was delivered, and the OOC secured the 10% POB reduction that was needed for the successful delivery of the project [12].

Fig.3 Andrew OOC with visualization, mudlogging and MWD workstations

The only problematic implication of this low-key implementation strategy was that the OOC was not promoted as part of a greater vision of integrated operations – the operations team simply had yet another task to prepare for. The focus on POB meant that it was more difficult to sell the potential for better decision making to the wider audience:

"I don't know if management made it clear what the purpose was. We were great at putting brochures together when [it was] deemed a success, but did that actually happen in the first instance? I don't think that it was broadcast outside the team."

Code of Conduct

The University of Aberdeen was asked to assist in drawing up a Code of Conduct for all involved parties, to minimise disruptions for the driller and OOC staff and to raise awareness for the OOC. The code specified responsibilities and good practice for each user group, emphasized the cooperation required during the change process and asked everyone to speak up about problems and concerns. It was used as a basis for briefing onshore and offshore crews about the rationale and purpose of the OOC. Contingency plans for all major risks, such as fibre failure were prepared and discussed with the OOC staff at a Hazop meeting, **Fig. 4**.

While every effort was made to include all end-users in the briefing, it remained a challenge to fully involve the offshore crews. The ideal solution would have been to use the OOC for briefings before crews went offshore but because of timescales this was not deemed practical for Andrew. Our impression from heliport meetings was that offshore staff knew about the purpose of the OOC but still harboured some concerns.

The research continued during the drilling operations with regular observations and interviews. Two parts of the findings will be discussed in this paper: the attitude measurement before and after the project, and a human factors evaluation of work in the OOC.

1. Measuring attitudes to change

Soft factors, such as people's suspicion of a hidden agenda in a project, can have an enormous impact on its success, yet they are difficult to quantify. There are however ways to measure attitudes in a systematic manner. One of these instruments is the Qsort, a card sort technique [15] that can be used to explore diverse opinions on a given topic. A number of statements relating to the topic are presented on cards and participants are asked to sort these in order of the strength of their agreement, **Fig. 5**. The method is more acceptable to people than questionnaires, encourages personal contact and provides more information to interpret the numerical results. All responses are collected in a standard format, which enables the results to be analysed statistically. The results show how homogenous or diverse the opinions are.

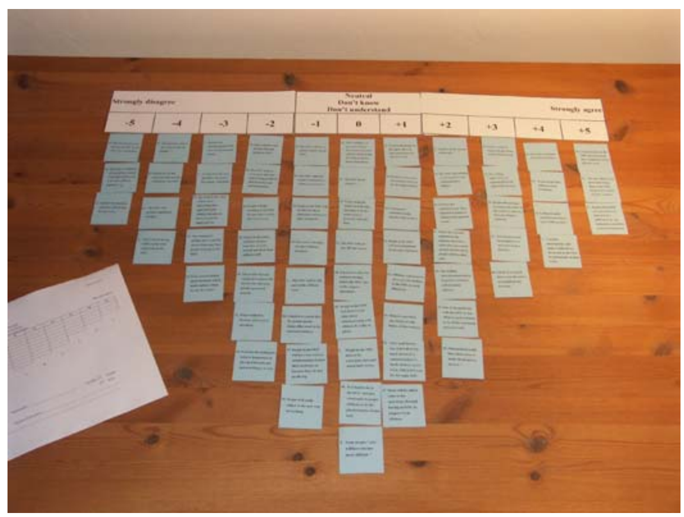

Fig. 5 Card sort task for measuring attitudes

For the Andrew project, a Qsort study was carried out before the commencement of the OOC and drilling operations in January 2005 and again at the end in June/July 2005. In January 33 team members took part (13 ops team and contractor coordinators, 5 OOC and 15 offshore staff). In June it was only possible to recruit 23 team members (11 ops team and contractor coordinators, 5 OOC and 6 offshore staff). A total of 76 statements were used, all of which had been derived from the initial research and interviews in Norway.

All participants were asked to explain their agreement or disagreement and their comments were recorded and transcribed. The data was analysed using factor analysis, and three different groups of people with distinct opinions were identified. The same groups were identified at both the beginning and end of the Andrew project. These three groups were:

1. Designers/management and informed others who believed in the success and thought that onshore supported operations were the future of the industry.
2. Critical users who paid high attention to the possible risks of remote operations. They did not believe in better decisions, reduced workload or a positive impact on their own work.
3. Positive believers offshore and onshore who strongly believed in the positive impact of onshore centres on drilling operations and their own work. They did not perceive the risks of the change and were even more positive than the designers/management.

1.1 Management perspective

The first group consisted of 15 people (10 in June) mostly from the onshore team but also contractor coordinators and drilling supervisors who shared a strong belief that onshore supported operations were a successful concept and would increase in the future. The following quotes provide examples of the benefits seen by this group:

"We had some tool failures or some data interpretation issues in which we were able to bring in the expertise from onshore, and they were able to communicate to offshore and determine where they want to run the log, where they want to do the repeat sections before they were satisfied. If the OOC were not there … it would have taken two - three days before the experts could have seen the log and made their conclusions."

"I've found that I can learn a lot more from it. I get to see different systems. It also helps having all the displays on the screens and the videos, and having someone there all the time. I'm much more a part of the operation and sort of constantly aware of what's going on. I can just phone the OOC because someone's there 24hours that I can get a quick update off."

The views held by people in this group can be seen from the statements that they strongly agreed on in comparison to the other groups. They state the pragmatic drive for the Andrew OOC as well as the positive expectations towards remote operations.
"The main purpose of having an OOC in our case is to reduce POB."
"I believe in the success of the OOC."
"Onshore supported operations are the way forward."

Asked the same questions again in June 2005, the POB reduction no longer featured among the statements of strongest agreement. Instead, three statements expressed that the OOC was successful and the way forward, and it was also seen as allowing for more efficient decisions. People in this group disagreed with statements about negative side effects, such as high workload during the dayshift or using staff as guinea pigs for some big idea. As some of these side effects had already been observed before, the findings show that this group did not anticipate or acknowledge the problems or anxieties the introduction of the OOC might provoke in other members of the team.

1.2 The critical offshore / OOC perspective

The second group consisted of 9 people (7 in June) mostly form the offshore and OOC constituency (but also two onshore team members in June) who expressed critical views about the OOC and concerns about possible risks and negative consequences. Members of this group strongly agreed about the following statements, expressing an offshore perspective on the limitations of remote operations:

"Offshore experience is necessary for workers in the OOC to work effectively."
"You lose the feeling for what is happening on the rig when you are just watching a screen."
"People in the OOC have to be constantly alert and watch their screen."
"People will not want to work in the OOC if the contracts offer less than the offshore contracts."

The following quotes provide further explanation why they felt the OOC had made their work more difficult in terms of offshore workload and the remoteness from the actual operation:
"The guy offshore was doing longer in hours then he should have done may be and if there'd been somebody else he would have gone to bed and the other guy would have taken over. When anything goes wrong, which it did on occasion they were having to do extra hours."

"I had to suddenly teach them about our gas system and he has still got his own job to do and now he's got mine to do as well. But you can't leave a rig sitting idle, you have to get on top of it."

"You don't get the chance to relax during meal time. You're just solidly stuck here [in the OOC] for 12 hours."

"It's very difficult to maintain the fact that effectively you're on the rig. The jobs offshore are more interesting; it's interaction with people, it's seeing how the job is progressing in a much more immediate way."

The members of this group also disagreed with statements that OOCs would ultimately provide a better basis for conducting drilling operations and that the work would be easier or no one would eventually work offshore anymore.

At the second testing in June, only the strong agreement with the importance of contracts and pay and the non-reduction of workload remained significant. The good news is that the people in this group rejected the notion that management would use the centre to spy on people – this "big brother" syndrome [2] had been an issue in previous OOCs but in Andrew, any initial scepticism about surveillance and control had obviously been eradicated during the project. Even the members of this group generally reflected positive on the

OOC experience and would work there again, provided that their remuneration was not at stake.

1.3 The offshore positive believer's perspective

The third group of people consisted of four people, three OOC staff and one offshore team member, who were labelled "positive believers" as they shared the belief that onshore supported operations, would present an added value for operations. The following statements were sorted as "strongly agree":

"There will be added value to the operations through having an OOC to support work offshore."
"Communication in the OOC has to be much more explicit to ensure effective work"
"The OOC will produce significant savings."
"What worked in Norway will work in Aberdeen."
"Work becomes more meaningful when you get the bigger picture."

Two of these statements remained significant at the second testing in June: the similarity to Norway and the need for more explicit communication. In that sense the meaning of this group has become less explicitly positive. This group also disagreed that there would be substantial risks, such as power and communication failure or lack of situation awareness.

After the experience with the OOC, this group attested that the OOC had been well prepared and working well. However they also stated that the OOC had no positive impact on safety in terms of their own safety behaviour (rather than the reduced number of personnel exposed to the risk of offshore work). Respondents in this group assumed that there would be cost savings as fewer personnel were required or no offshore rates were paid. Neither was in fact the case, and it is not clear how the impression was created.

While our study clearly identified differences in opinion, the content of any "official" internal or external publication such as the leaflets and the CD produced by the Andrew team is likely to be biased in favour of the onshore management perspective and be oblivious of the concerns expressed by the second group. On the other hand, the management team were more critically aware of the limitations of the current pilot, while at least some offshore respondents were apparently completely convinced of the potential of the concept beyond what the Andrew pilot actually delivered.

2. Impact of the OOC on job design

The following section is concerned with the actual jobs within the OOC from a human factors perspective. The three positions relocated to the OOC onshore were drilling monitoring and support jobs provided by a service company with a track record of OOC services in Norway. The tasks in the OOC consisted of remote monitoring of real time drilling and geological data, checking data quality, preparing tools, setting up of programmes and compiling logs, **Fig. 6**. To a large extent, the actual work remained the same as offshore, which requires vigilance and quick reactions to prevent a potentially critical situation from developing into a sudden emergency. The tasks also include communication with the drilling crew, the operator's team onshore and experts from the service company.
Up to this point, the implications for job design within the OOCs had been not explicitly addressed. As part of the Andrew project, an effort was made to analyse OOC work in terms of criteria for human-centred job design that have previously been shown to influence well-being, motivation and operational effectiveness [16].

2.1 Function allocation human - machine

Remote operations represent a special case of computer-mediated operations, which require decisions on which tasks should be allocated to a human operator. The traditional strategy in many industries has been to reduce human exposure to risk and to minimise the impact of human error, so humans are removed from the actual operations and only given supervisory control to stop the system if something goes wrong. This however poses problems referred to as the "irony of automation" [17].
"One day in ten, fifteen, a hundred years, we won't have any human exposure. We will require more complex structures in future but we should be able to take away the human … Even if we get to the point of having [only] one person offshore I think that person would still like to make a final decision if anything has to do with safety."

The logic of this argument, albeit appealing, implies that the very same error-prone humans suddenly become capable of dealing with a misbehaving system that they previously had to be removed from, with little opportunity to practice the skills required in the event of disaster. A better strategy would be to employ the specific human skills in problem solving and automate tasks that place unnecessary strain on humans.

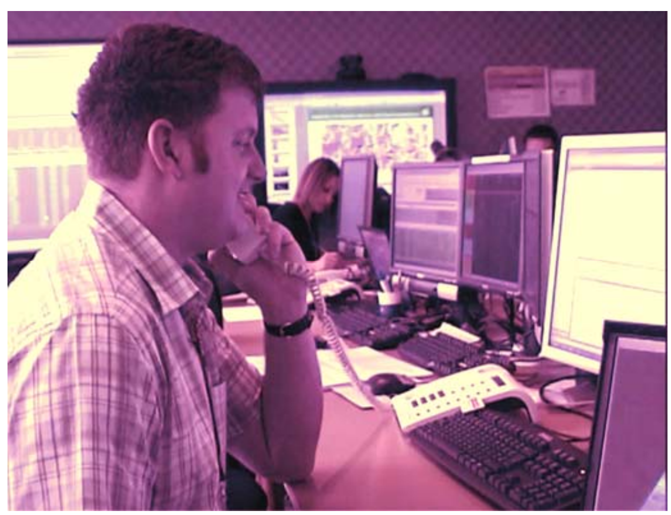

Fig.6 OOC operator at work – monitoring and communicating

2.2 Task completeness

People are more likely to feel responsible and satisfied if they are involved in the entire task from determining the objective of their work to conducting the actual work and obtaining feedback about outcomes. The Andrew OOC was not specifically designed for integrated operations. The involvement consisted of information sessions and a Hazop meeting during the preparation stage. Apart from that, the work in the OOC was largely kept the same as offshore, with the difference that the OOC staff received less feedback on outcomes and could no longer personally check their equipment.

"It's harder to feel ownership for an operation from a distance … it's subtle things like when you're offshore you can feel how the rig is moving or you hear a different noise, so for the mud loggers when the pump stroke counters start kicking or the draw works starts moving, they know that something has changed."

2.3 Task variety

Task variety can counteract monotony and help to avoid fatigue, de-skilling and strain. Any jobholder should perform a diversity of actions that involve different cognitive demands and skills. Human operators are typically good at interpreting the meaning of complex patterns, yet constant vigilance is difficult and straining for humans. Most of the work conducted by OOC staff essentially consists of monitoring the well, a task not ideally suited for humans. Part of the former variety was lost as manual tasks had to be carried out offshore.

"It's a bit boring sitting in here the whole time. It's more varied offshore: You do the physical work; you're meeting people. It's a sedentary sort of job sitting behind a computer all day."

2.4 Process control and feedback

The criterion of process control means jobholders can influence the relevant parameters that determine efficiency and quality, and they receive information about the outcome as quickly as possible. The opinions varied whether or not the OOC provided a "sense of being there" based on the cameras on the drill floor and the real-time drilling data.

"If anything, we get a better view here because in the MWD unit you usually don't have a window; you're locked away somewhere and you can't see the rig floor. We get the cameras and we see the data on the screens that we would see in the MWD unit, and we can speak to the driller or anyone else for that matter on the intercom or the telephone, so we've got as much if not more sources of information."

On the negative side, the OOC staff had little control over who entered their room, which interruptions were perceived as annoying at times.

"I've had a few examples lately whilst we've been working in here; we've had constant people coming in the whole time. It's not the fact that they're talking to us specifically, it's the fact that they're talking to one another. We had a few problems the other day and really had to concentrate and it just gets your back up a little bit because you're trying to concentrate and it's all going wrong."

Interruptions and visits seem to have been less of a problem then anticipated. However, the veto rule in the Code of Conduct, which allowed staff to turn away visitors, was never actually used. The OOC succeeded in increasing awareness and feedback for onshore management who made regular, brief visits to the OOC to maintain awareness of what was going on at the rig.

2.5 Time flexibility and planning

Jobholders should have sufficient time to carry out their tasks at their own speed, not at a pace dictated by the technical system. The nature of drilling operations means that this criterion is never completely met because crews have to respond to events and monitor data. The observations indicated that normally there is sufficient time to respond and to plan ahead for the next step. The current trend towards monitoring several operations simultaneously is however problematic from a human factors perspective, as it places the operator under more constraints than advisable, as the experience in NASA has shown [18].

2.6 Cognitive requirements

Tasks should be designed so that they allow for individual goal setting and involve adequate mental challenge. The work in the OOC fulfils this requirement at least as much as offshore, if not more. Most respondents felt that the OOC project was interesting and welcomed the exposure to new technology, if only for the benefit of their CVs. The actual work in the OOC featured challenging and stimulating periods of time as well as "*getting bored, sitting around when nothing happens*".

2.7 Communication and cooperation

As humans have social needs, work should involve task-related communication and opportunities for face-to-face contacts. As the Andrew OOC was not designed to support integrated operations, this criterion was not met. The OOC was located further away from the operations team's office and was seldom used for collaboration purposes.

"There was a collaboration piece within it but I don't think that that was as strong as it could have been. Also the room really wasn't set up for collaboration, so may be that would be something that would evolve over time."
"There's probably less teamwork for the people working in the OOC because they're more isolated from the day-to-day operation offshore. They're not interacting with the guys off shift, not playing snooker, watching television, sitting in the smoking tea-shack."

Nonetheless the work in the OOC increased the contact with onshore team members and involved a high degree of communication. Since face-to-face communication was no longer an option in interacting with the rig, communication had to become more explicit:

"Especially when you're explaining to a colleague offshore what to do, you've got to be fairly good at explaining things and it's a bit harder because you can't go and show them physically"
"For these jobs you need [drillers] that are willing to take the time to listen on the phone because you get so much more across in body language being there all the time. On the

phone you have to be specific to what you want and have to describe a lot more things. So they have to be more patient."

Using digital cameras or scanners to support remote collaboration could reduce some of these issues.
"I was asking [my colleague offshore] to check for certain things and he couldn't even understand what I was asking for. If we'd had a scanner or a drawing tab that would be a lot easier. Like with a digital photograph, he could have just shown me and I could have seen what he was talking about."

2.8 Learning opportunities

Learning opportunities means that a job should offer new experiences and encourage skill development. This criterion seemed to be fulfilled for work in the OOC as jobholders are more exposed to new tools and technology, more involved in the wider issues and can learn from each other.

2.9 Physical activity and wellbeing

For health and wellbeing, any job should ideally involve some physical activity. This is largely the case for offshore work, yet in the OOC the job was restricted to desktop/PC based work. In terms of safety, the beneficial effect of the OOC was that fewer people were exposed to the risks of offshore work. However, staff did not necessarily appreciate this as they thought about behavioural safety in the OOC and on the rig, on which the OOC was not likely to have an impact. Other wellbeing issues of OOC work concerned the provision of food and the ergonomics of the equipment, which were not ideal but appropriate for a pilot project.

2.10 Work-life balance

The biggest impact of the OOC was on life style. Some described the difficulties they experienced in adjusting to the new working environment as *"You are putting an offshore person in an onshore environment."* Offshore everybody works, eats and sleeps on the platform; all practicalities such as food and laundry are taken care of. In the OOC, staff had to commute after a 12-hour day or night shift and prepare their own meals. Some said they missed the informal camaraderie and immediacy found on the rig. In those centres that operated 8-hour shifts, some reported as beneficial that they could lead an "almost a normal life" and see friends and family on a regular basis. Yet both in Stavanger and in Aberdeen, OOC staff reported difficulties in adapting family life and returning home after night shifts to children who were used to having quality time when their father was home. The impact on work-life balance seems to be not entirely positive.

Conclusion: the impact of remote operations

It is likely that the introduction of remote and/or integrated operations will considerably change the industry. The following section provides a summary of recommendations for future OOC projects based on findings from the research.

1. Consider the impact on job design and skills

The introduction of remote operations is likely to impact the required skill set, roles and responsibilities. While the tools and measurements were innovated, the division of labour has largely remained the same. Both onshore and offshore, jobholders could be trained to span traditional roles and disciplines so that offshore staff could handle a diverse range of equipment and drilling engineers would become more aware of both well placement and reservoir engineering issues.
The **implications for the actual work** in the OOC and offshore should be considered at the design stage. Currently, OOC work is perceived as less exciting, less collaborative and more negative for work-life balance than offshore work. This could change if the needs of the users are attended to during the design and implementation.
If an OOC is intended as a true collaborative environment, it needs to be set-up to in **close proximity** to the operations team to facilitate easy interaction with all whose expertise might be required. Any physical barrier will reduce interaction. Glass walls not only symbolise transparency, they also create more awareness within the team, as the Operations Centre in Schiphol Airport shows [19]. They also make it easier to satisfy outside interest, without too many interruptions and "zoo visits" to the OOC.
Any **contractual changes** could become a matter of dispute. To avoid rumors, communicate clearly if and how changes are to be made.

2. Involve people in the change process

So far, the implementation of change has mostly affected the work of contractor staff, who tended to be the last to know and the least likely to be involved in the design. Only the contractor staff switched to a 24/7-shift system, which created a string of unexpected minor organisational issues that the operator's organisation was not fully prepared for. The design was driven by pragmatic and technical reasoning and led to a further manifestation of division of labour between "thinking" onshore and "doing" offshore.

It is therefore vital to involve contractors as early as possible in order to obtain helpful advice on practicalities and to allow them to commit resources and staff to the project. Ensure that the actual jobholders can **participate in the preparation,** through workshops and Hazops etc. The fact that a colleague from the same company has attended a briefing does not guarantee that the learning will be shared, or that the second-hand report is equivalent to the experience of actually being involved. Interactive training with dynamic scenarios is more effective than one-way communication.

Other key ingredients for successful implementation are a passionate project leader and open communication of the **vision and purpose.** Aim to make integrated operations more than just real-time data transfer: The added value of OOCs is in providing an environment for better informed and validated decisions.

3. Allow ample time for planning and testing of equipment

Both old and new infrastructure has produced unexpected complications. Equipment that is not working properly, not only hampers effectiveness; it also sends the unintended message to the crews that the company does not care. Offices are not normally set up for 24/7 operations. **Access, transport and food** need to be in place in good time. Facilities for breaks or rest and use of pagers or mobiles phones can reduce the negative impact of long periods of low engagement and monitoring, preventing fatigue. It is advisable to prepare and budget to **capture lessons learned** during the project and to collect data on the prevention of non-productive time in order to substantiate the claim of added value.

4. Ensure that the design meets the strategic objective

The comparison of different centres showed that the drivers for innovation were very distinct in all cases and that existing work practices were moulded according to those intentions. While in Norway the discussion was strongly influenced by public opinion and governmental efforts to influence health, safety and work-life balance, the UK project was mainly driven by commercial reasons. Depending on the age of the rig and the time available for planning and testing, different technology strategies were adopted. While it is essential to maintain IT standards for interconnectivity, the design and organisation of an OOC should always be determined by its specific purpose, the organisational readiness for adopting new work practices, and the level of technical sophistication available at any given location.

5. Remote operations require trust

Remote operations require system reliability and trust between stakeholders in order to function appropriately. In the same way that pilots need to trust air traffic control, drillers need to be able to rely on the distant support and management on the quality of the data they receive. The irony of remote operations is that trust becomes even more important in a situation in which it is least likely to develop: Trust is normally the result of continuous positive interaction and is more easily built up in face-to-face contacts. If remote operations become more widespread, people will need to rely on a system, rather than a trusted colleague, to provide a high quality of service. In the onshore situation, contractors will become more involved with and exposed to their clients. This requires a different form of collaboration and "trust" between organisations in order to share not only data but also hick-ups and procedural problems. In Andrew, the OOC staff felt more confident in a room to themselves where they could deal with any issues internally first.

6. Engage wider audience in debate of socio-economic implications

Remote operations will also influence what type of work will be available in certain regions. E-operations can help retain jobs in areas that would otherwise be declining. But they could also concentrate the labour market around the location of OOCs. Norway, one of the global leaders in e-operations, is beginning to notice some public debate on these socio-economic implications [20]. After the decline of the fishing industry a lot of remote communities still thrive, partly due to their participation in offshore jobs. The introduction of OOCs has not only moved jobs onshore, but also to certain places such as Stavanger. If this move continues it may keep jobs in Norway, but it could put small, remote communities at risk by requiring entire families to relocate. The increase of remote operations should therefore be discussed at a strategic level, with the involvement of all stakeholders including local government.

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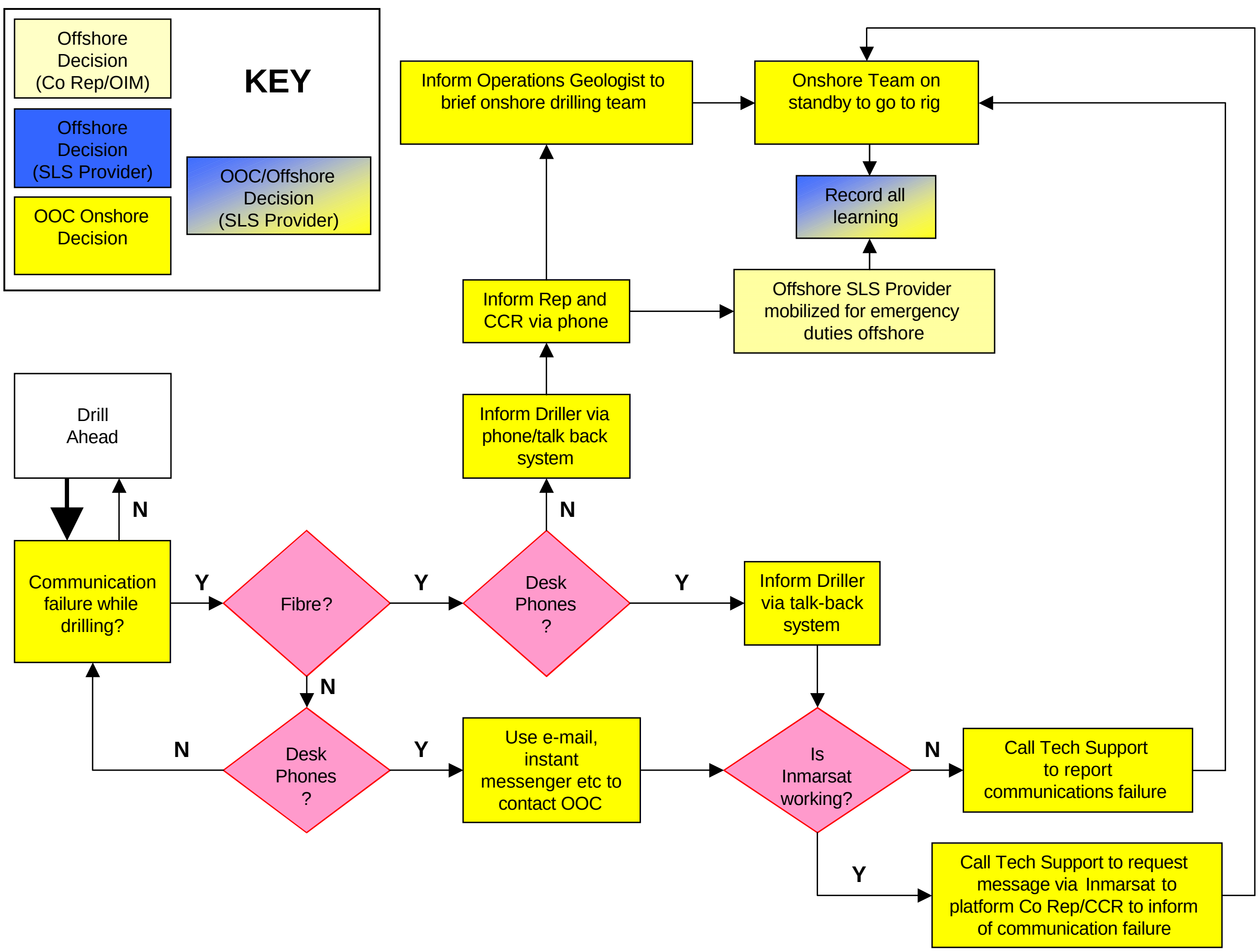

Fig. 4 Decision tree to be followed in the event of fibre failure