SPE-167841-MS

The Future of Telemedicine in O&G

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This paper was prepared for presentation at the SPE Intelligent Energy Conference and Exhibition held in Utrecht, The Netherlands, 1–3 April 2014.

Abstract

This paper presents an ongoing work in on the future of telemedicine in O&G. There has been a huge development in the use of video consultation between remote patients and the doctors. We believe the future of telemedicine in O&G will add to this workflow by investigating how we can transfer visual **medical data** between “offshore nurses” and “medical experts” at hospitals onshore in order to improve diagnostics and treatment. We will describe a **decision support system** that supports an optimal workflow and collaboration, between medics onshore and offshore. The goal is to make better and faster medical decisions, and improve the quality of healthcare offshore.

The oil companies have much of the same structure and same challenges in **remote medical treatment**. We investigate an **optimal workflow** including how technology supports a new telemedicine work process by transmitting very high quality information (e.g. ultrasound images) to the cardiovascular medical experts.

We will review our work on developing a prototype **“on the go” solution** between medics offshore and the medical experts onshore at the hospital. The concept will be based on a Pad/PC solution capturing the ultrasound image transmission between the user and experts, a systematic work process and a knowledge base integrated in the Pad/PC “on the go solution”. With optimal workflow it should not take more than 5-7 minutes from the starting point to have a decision from the medical expert. This will improve diagnostics, medical safety and health quality on offshore installations.

Introduction

Background

The European Health Telematics research programme in Advanced Informatics in Medicine (1991), has defined telemedicine as “the investigation, monitoring and management of patients and the education of patients and staff using systems which allow ready access to expert advice and patient information no matter where the patient or relevant information is located.". Later definitions of telemedicine seem to highlight the exchange “of medical information from one site to another via electronic communications to improve a patient’s clinical health status” (The American Telemedicine Association). What we have seen for the last decade is that telemedicine includes a growing variety of applications and services using two-way video, email, smart phones, wireless tools and other forms of telecommunication technology. Due to the development of Information and Communication Technologies (ICT) and the digitalization of information we have experienced a window of opportunities for healthcare at a distance. We now also see that the term telemedicine stands next to terms such as e-Health, TeleHealth, Digital-Health, Tele-Care, Medical Informatics or simply ICT for Health or Health Telematics. Telemedicine is often referred to as `the actual delivery of remote clinical services using technology`. Concepts such as TeleHealth, e-Health and others seem to be broader and go beyond the delivery of actual clinical services. In our specific case, the working definition highlights that telemedicine, in the context of O&G industry, is practiced when you have decision-making support located at a distance from those who request such support.

A main reason for the interest in telemedicine is its potentiality for improving medical services at remote sites, whether we are talking about isolated, hardly accessible rural areas or offshore installations. For many years, telemedicine has been a topic of great interest to both medical and technological communities. Since the 1960s there have been numerous attempts to develop telemedicine programs (Thrall and Boland, 1998), and in the 1990s, interest in telemedicine grew due to technological advances with digital data transmission and greater bandwidths (Thomas, 1998; Thrall and Boland, 1998). Most of the early applications of telemedicine involved communication over telephone lines using satellite, microwave or cable as modes of transmission (Michaels, 1989) for medical consultations. In addition, attempts were made to use closed circuit television as a communication tool between physicians and patients, as well as to transmit radiological images (Thrall and Boland, 1998). Several advances in telemedicine have been made over the years in line with technological developments, resulting in increase of telemedicine applications.

In the concrete case of the offshore oil and gas industry, their operating locations are challenging for delivering emergency medical care to personnel due to both remoteness from land based medical care, and their dependence on weather conditions for evacuations (whether by helicopter or boat). According to previous literature, since the 1970s, telemedicine by use of telephone has been applied on several offshore installations (e.g. Evensen & Fjærtoft, 2008). Identified advantages of using telemedicine in oil and gas installations offshore have been: reduced number of unnecessary evacuations, shorter response times, early initiation of treatment in critical conditions, and increased perception of safety by offshore personnel (e.g. Anscome, 2010; Mair et al., 2008).

The common implementation approach of telemedicine in oil & gas industry has been to use telemedicine as a way of having supervised practice of the offshore medical care through establishing a live video link between the offshore hospital bay and an onshore physician, allowing the physician to perform diagnostics and often initiate treatment while the patient is still offshore (Anscombe, 2010; Boultinghouse & Fitts, 2013; Godfrey, 2010).

From what is described in both published studies and in direct contact with companies operating in the Norwegian Continental Shelf (NCS), today's telemedicine systems for offshore operations typically comprise a video conferencing system and medical equipment such as digital stethoscope and multipurpose high-resolution magnification medical scope for examining ears, nose, throat or skin. In addition, many have installed equipment that allows the offshore medical personnel to perform ECG recordings, ultrasound recordings, and X-ray and transmit these to a medical expert onshore for interpretation (Evensen and Fjærtoft, 2008; Godfrey 2010; Mair et al. 2008; Mika et al. 2009; Webster et al. 2008, Kjemphol 2012).

The interpretation of such medical recordings (e.g. ECG image) may then be done in real-time through a live video link between the offshore medical personnel and the medical experts, but the transmission of the data does not seem to be as seamless. From the moment the offshore medical personnel obtains the medical data, until the moment the expert physician can access it and decide accordingly, it is often necessary to go through several steps such as changing information support systems – for instance change information from email to fax – and a number of intermediaries. These issues are due to a combination of requirements and legislation, and an inefficient implementation of new technology tools in telemedicine that are not integrated with the rest of the system.

The main goal of the current project is to establish a new telemedicine practice that improves healthcare services in offshore installations. We intend to achieve this by developing and implementing a telemedicine Decision Support System that incorporates available new medical technologies to assist in diagnostics, reduce response times, and improve quality of medical decisions. We are exploring aspects related to people, technology, organization, and governance, in order to outline best practices in workflows and processes to achieve successful implementation of such a telemedicine practice. The Norwegian Centre for Maritime Medicine highlights similar dimensions in their consensus document on maritime telemedicine (IMHA/NCMM, 2013). The consensus document is really a start on a joint effort in maritime telemedicine as a whole, including competence needs, developing standards and databases for evaluating and improving maritime telemedicine. The similarities here, means that the project are on a right track with the broader community of maritime telemedicine.

Context

The current project is a continuation from an initial project in 2011-2013 focusing on the use of portable ultrasound equipment in offshore installations. The ongoing project "The future of Telemedicine in O&G 2013" has focus on work processes in telemedicine as its core activity.

The chosen approach in this project is based on the concept that "telemedicine is medicine". This statement was chosen to emphasize that the medical work processes and decision-making in telemedicine should not be different from medicine. We assume the same information is required and that the steps to achieve a decision regarding diagnostics and treatment are equivalent. The main difference between "telemedicine" and "medicine" concerns the physical location of involved roles. In the case of telemedicine, decision-making support is located at a distance from those who request such support, whereas in medicine, the role asking for support and the role that gives support are collocated. Today, many seem to think of telemedicine primarily in terms of video consultations. However, in this project we define telemedicine as the complete workflow and decision-making process from the moment the solution is activated until the moment a decision has been made and an action plan is initiated. The medical decision making process in telemedicine should be a mirror of real life collocated medical collaboration. By this definition we allow ourselves to look at the whole process and not simply be focusing on technological aspects of telemedicine.

Our main focus in the initial project in 2012 – 2013 was to achieve a telemedicine decision support system and workflow regarding the Vscan handheld ultrasound. The Vscan handheld ultrasound is a strong example of miniaturization of advanced medical technology that makes them well suited for use in remote areas. The pre-project had though, a much larger framework regarding perspectives on the future of telemedicine in O&G. The scope was to achieve a telemedicine decision support system and workflow regarding the Vscan handheld ultrasound, understand the ongoing telemedicine practice and explore potentials for a new telemedicine practice. The main goals for the pre-project were:

- Perform a pilot where offshore nurses could share ultrasound data with onshore cardiologists.
- Study the relevance of objective information for decision support
- Medical training of offshore medics (nurse anaesthetist) in video conferencing and new digital medical equipment.
- Explore how such a tool (portable ultrasound) can facilitate faster and better decisions.

Key results from the pre project are here summarized (See also Report Telemedicine in O&G 2013):

a) Recognition of the quality of ultrasound images: eight nurses from an oil company operating in Norway received training to be able to use the Vscan handheld ultrasound device. The training was conducted at NTNU, MI Laboratory, Department of Circulation and Medical Imaging, Norwegian University of Science and Technology. The nurses were taught how to examine the patients and all were able to acquire cardiac ultrasound images of such quality that experts were able to get important information on cardiac function and pathology.
b) Ability to diagnose medical conditions: among the volunteers that were scanned by the offshore nurses there were some findings that suggested the need for further medical follow-up onshore. These examples show that the equipment improves diagnostic, medical safety and health quality on offshore installations.
c) Assessment of the tested telemedicine practice: the nurses, as well as the medical experts at St. Olav Hospital expressed that they were very comfortable with the collaboration established during the project.
d) Relevance of improving health care offshore: the nurses acknowledged the high quality and relevance of the medical data and equipment, as well as enhancement of their skills, by using a new diagnostic tool such as the Vscan. This development ensured trust in the overall HSE service offshore.
e) Telemedicine workflows: throughout the project we noticed the lack of a telemedicine decision support system that includes all the available medical information from the offshore patient examination. According to the experts, after having the key medical information they can make decisions within 3-5 minutes, however, in the current work setting for telemedicine, it takes much longer to get access to the medical data, since it is not available directly.

These results triggered the motivation for exploring a new telemedicine practice in the current 2013 project. For the current project we count with the participation of another oil & gas company in Brazil, trying to explore the potentials of a new telemedicine practice. A Brazilian Hospital, with an ongoing telemedicine program in Brazil is also a partner. A research institute from Norway has joined, focusing on the topic of workflows for telemedicine, using an integrative approach to understand what is required from the organization to implement a new telemedicine practice. To explore the telemedicine practices in companies operating in Brazil and Norway, the issues of governance have a determinant role: different rules, laws and contexts.

Current Project

In the on-going project, “The future of Telemedicine in O&G 2013” – we are following two major paths. One path focuses on understanding work processes and workflows in telemedicine and is achieved through a capability approach (e.g. Henderson, Hepsø, & Mydland, 2012), mapping what is required of the organization to implement a new telemedicine practice. The other path focuses on the development of a technological solution to support processes in telemedicine, generating and testing a prototype system for data sharing.

With these two paths we intend to demonstrate the functionalities of a telemedicine prototype that enables a virtual examination room, as well as to present a broader scope for the work processes enabling a successful implementation of a future telemedicine practice.

Telemedicine Prototype

The goal for 2013 has been to prepare and do preliminary testing of a demonstrator of the different attributes of a telemedicine prototype “on the go” solution. This “on the go solution” is characterized by allowing easy access between the nurses offshore and the medical experts onshore with a “one button push” concept. The general and specific requirements of the demonstrator are being defined together with the main users – nurses and medical experts.

The telemedicine prototype “on the go” solution is an example of software for sharing medical data, enabling collaboration in different situations and based on optimal workflows between the offshore and onshore medical facilities. The basic objective for the prototype is to demonstrate some key functionality of a virtual examination room enabled by the telemedicine prototype “on the go” solution. This virtual examination room is a collaboration space where all medical data can be accessed and the decision making process may unfold in real time. This solution shall support an efficient and high quality decision-making process in different situations (for instance, emergency and normal situations). Figure 1 illustrates the concept of the virtual examination room, showing that medical experts, hospital and the offshore nurse can be simultaneously seeing, interpreting and discussing the medical information available in the virtual examination room that have been retrieved from the connected medical devices.

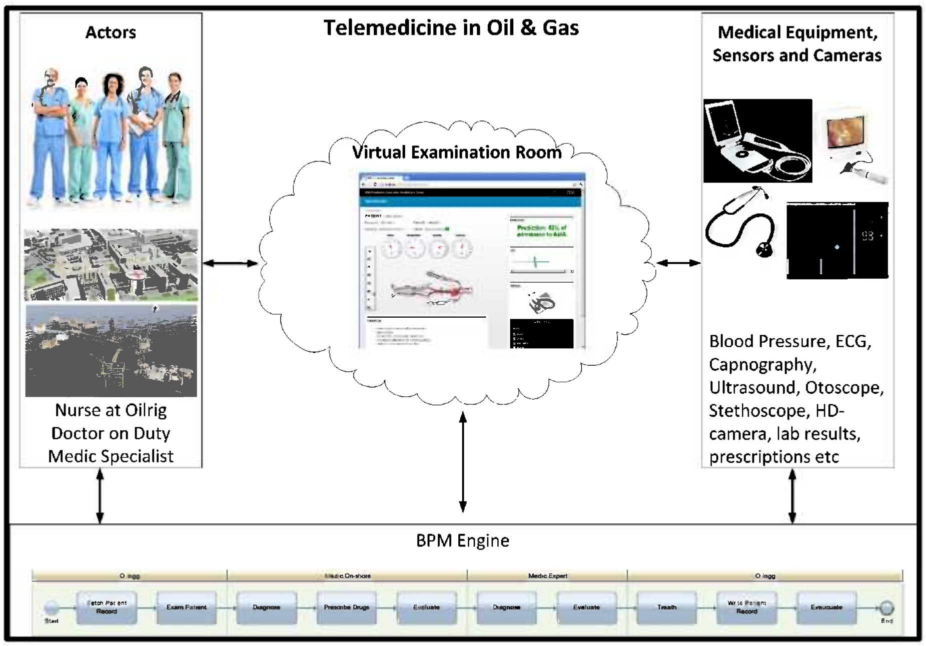

Figure 1: The virtual examination room

Currently we are running a pilot of the prototype solution. This pilot consists of three separate iterations that will allow the exploration of requirements and to test the retrieval of information from the medical equipment, the sharing of data, and the video-link simultaneously with the data sharing. Assessment of user experiences is planned in future steps and the prototype development is being done in close interaction with the future users. Insights from innovation projects, as well as projects on process optimization, show that action-based research is very effective for collaborative learning between users and researchers. (Davison, 2004) Further, future plans include the implementations of the solution in both computer and mobile devices, thereby allowing mobility for the experts, and further facilitating reduced response time when contacted by offshore personnel.

The capability approach

In an early stage of the project we understood that the development of a data sharing solution that improves the accessibility to objective medical data would also imply significant changes in the current work processes of telemedicine. As such, we started to develop a plan for mapping current practices of telemedicine with an oil & gas company operating in Norway, and simultaneously assessing the requirements and implications of the new prototype solution.

Together with the IO Centre Teamwork and Capabilities (IO1) team, we have applied the capability approach to the specific case of telemedicine. The capability approach implies an integrated and dynamic view of the organizational system, focusing on four main dimensions: people, technology, processes, and governance (e.g. Henderson, Hepsø, & Mydland, 2012; Drøivoldsmo, Rindahl, & Mydland, 2013). The people dimension is related to roles, skills, and experience; the technology dimension refers to the available equipment and their potentialities; process focuses on work procedures and practices; and finally, the governance dimension is linked to aspects such as laws, policies, and requirements. According to this approach, introducing a change in one of the dimensions (for instance, introduce a new technological tool to facilitate tasks) will impact all other dimensions, or it may not result in the intended impact because the necessary changes in other dimensions for it to be effective are not performed. Therefore, all four dimensions should be taken into account when planning modifications to ensure successful change. The interdependence of these dimensions to achieve robustness in a new telemedicine practice is in line with the International Maritime Health Association/Norwegian Centre for Maritime Medicine (IMHA/NCMM) consensus document (2013) that states the relevance of planning changes in maritime telemedicine attending to their impact in all related subsystems.

Our goal is to be able to understand current practices and simultaneously, to explore future expectations, goals, and needs as described by the people who are directly using telemedicine. In collaboration with the target companies we intend to outline a development plan that enables the company to continuously improve their telemedicine practice by attending to people, technology, process and governance aspects and aligning their resources.

So far, following this approach, we have been exploring current practices of telemedicine to assess the level of development in telemedicine. To achieve that, we have been organizing meetings and semi-structured interviews with people in key-roles for the process, such as the nurses, the medical director and supervisor, the medical experts, and also representatives of other companies involved in the work process. Simultaneously, trying to focus in a future optimal practice, we organized workshops to actively define objectives for telemedicine by exploring future visions and possibilities and anticipated challenges.

Main outcomes 2013

Defining telemedicine

The definition of telemedicine within the context of the current project was one of our initial goals. After some discussion among all the partners, the concept "telemedicine is medicine" has been elaborated as part of the workshops, interviews, and literature search in the project. Within the setting of the project, telemedicine is defined as a replication of common medicine practice, using technology to overcome distances. As such, in order to enable provision of adequate health care, the system should allow the collection and real time sharing of medical data, the discussion of options between different professionals and decision-making, approximating the decision times offshore to the ones we can find in an onshore hospital or clinic.

The decision to ask for decision support is executed when the offshore healthcare services want onshore medical expertise to help in the diagnostics or treatment of the patient. Generically, for this process, the telemedicine workflow is initiated after the nurse decided to activate the support system and ends when there is a final decision/action on the case.
Within this context, we were able to describe four main steps in the medical decision making process in telemedicine and also different scenarios for emergency and normal situations that impact on how to proceed. The type of situation and how the main steps unfold are highly flexible.

As such, the logical sequence for the process would imply patient monitoring, data sharing, decision making, and action. Figure 2 shows the main steps of the telemedicine process. Understanding these steps, the roles of the participants and the differences in operating contexts are at the core of this project in order to define a new telemedicine practice that enables an enhanced telemedicine practice.

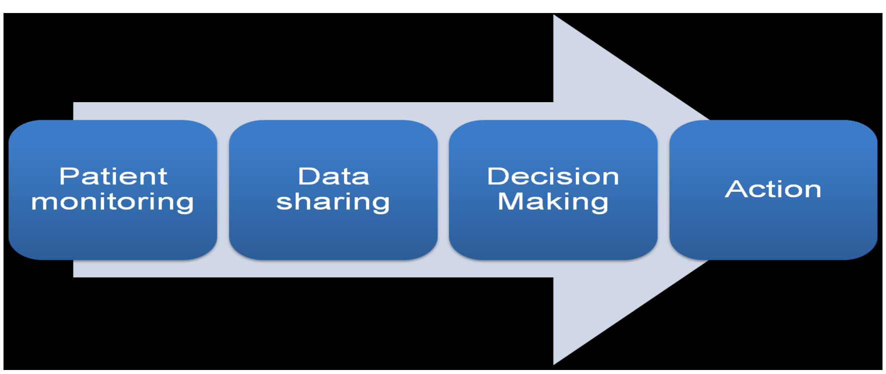

Figure 2: Main steps in the telemedicine practice

a) **Patient monitoring** includes all available medical information from the offshore examination of the patient. There are three categories of medical information: objective medical information from medical equipment; subjective medical information from the nurse/medic/medical expert; and history of the patient from medical records.
b) **Sharing medical information** will improve collaboration between medical personnel onshore and offshore. This

information should be easily accessed, reducing the response times. The quality of the decisions can also be improved as the medical experts can access more medical information themselves to facilitate the decision-making process. This will allow better quality of the healthcare services offshore.

c) **Decision making** is impacted by the kind of information that is available at a certain point. In some cases, the doctor may have enough information for diagnosis by just looking at the patient. Therefore, it is important that the decision support system is flexible so that the medical personnel, depending on their needs in the situation, can manage the collaboration process. For instance, the medical expert may wish to talk to the patient first and then ask for different kinds of medical information before making a decision, or he/she may request only objective medical information before making any decisions.

d) The **Action step** points to activities to be performed after the initial assessment, either to improve the diagnostics of the patient, or to provide care and treatment of the patient. We can identify some main categories of actions resulting from the initial assessment: treatment of the patient can be handled offshore; patient needs to be evacuated as soon as possible; further diagnostics and treatment of the patient should take place onshore by doctor or hospital, but emergency evacuation is not necessary.

Mapping of current telemedicine practices

Today´s medical information is distributed from offshore nurses to onshore doctors by fax, email, streaming of medical data, telephone or by videoconference. One identified difficulty is that the onshore experts are not available to immediately access the medical data and are not able to have a direct contact with the patient. The current set-up requires an intermediary (oil duty doctor) to build the telephone link with the expert (for instance, in cases where a cardiologist's opinion is required). Another issue is the time spent to have the videoconference system working with the doctor in the other end: according to the descriptions, this is what most of the time in the consultation process is spent at. The `on duty doctor` is available 24/7 on the phone, not in a videoconference setting (although they are reachable through videoconference also). As such, although the videoconference systems have improved a lot, it seems that telephone still is the major communication tool between the onshore and offshore medical facilities today.

A frequent request from the medical experts is related with easy access to objective medical data: being able to read and interpret data from ultrasound or ECG directly can be a valuable asset for their decision. Beyond the valuable information given by the nurse's initial assessment of the patient, being able to directly see and talk to the patient also seems to be considered a good set-up for some clinical situations. As such, the telemedicine apparatus should allow the transmission of subjective data (talking with the nurse or the patient) and objective data (accessing the medical devices data and seeing the patient). These features should be accessible and flexible enough to allow differentiated practice according to the different situations and patients.

Exploration of future visions of telemedicine

Throughout this year we have been exploring the major long-term goals and expectations that have been driving the different people involved in the telemedicine project, from the nurses to the management, including medical experts and other companies involved in the current practices. From the data we collected so far, the participants share the view of a future of telemedicine that allows safe and quality health care regardless of patient location. The potentialities of technology are numerous, but part of the challenge is related to the implementation and integration of desired telemedicine practice with the organization's existing processes and with the specific legislation and requirements of each country and operating context. The initial reasoning of this project relied on the belief that telemedicine practices would require major adaptations to the continuous developments on medical technology that have been presented in recent years. The trend to create portable versions of complex equipment such as ultrasounds opens the opportunity to better equip the offshore facilities and might dramatically improve the potentialities for diagnostics and treatment in locations far away from hospitals and medical experts. Advocating future practices in telemedicine, we are attentive to the roadmap for multidisciplinary care teams, enabling applications and planning for future developments in video consultation, visual data transmission and remotely operated actuators (ALLIANCE 2010), as well as the IMHA/NCMM (2013) consensus document.

Telemedicine prototype

The current work with the telemedicine prototype is allowing us to define requirements for the solution through the contact with the final users. So far, the following key features are identified:

- Video and pictures shall be of such quality that it is possible for doctors to ascertain a diagnosis.
- The virtual examination room can be accessed "on the go" by smart phones/iPads or similar mobile solutions.
- The virtual examination room shall be accessible to the experts in the same or in less time than current systems.
- The pilot test shall prove that the offshore healthcare services and the medical experts onshore can access the medical information in the virtual examination room at the same time.
- The decision support system offers a video link to establish a contact/collaboration space on the `go`.
- The system can retrieve vital medical data and provide the medical data to the virtual examination room.

- The data stored in the system shall conform to the same legal, safety and security standards the domestic HIS systems are subject to.

Future work

Plans and expected results

In 2014 the project will be developed in three major paths. One path is focused upon improved understanding of the work processes in telemedicine through a capability approach. The other path is considering the consequences for safety implied in the studied workflows, especially patient safety. The third path is a demonstration of different attributes of a telemedicine prototype “on the go” solution.

The studies during 2014 will help us to understand the contextual constraints and opportunities that can influence the implementation and operation of a new telemedicine practice. We are aiming for an incremental and holistic approach to move from present to desired future practices.

The final goal is to bring a synthesis of the results into a business case for a new telemedicine practice. This business case will target the benefits but also organizational challenges resulting from the implementation of a new telemedicine practice. Insights from current work highlight that differences in context influence the rules for the business case, but our work aims to support companies and organizations to build their development strategy for a new telemedicine practice.

Work processes and capabilities

Future work on the topic of work processes and capabilities include a thorough mapping of people, technology, process and governance in both oil companies, and the test of specific workflows in using telemedicine according to scenario types in order to select good and efficient practices. We will be elaborating on and evaluating a methodology to develop telemedicine within the organization, collecting good practices and recommendations and drafting a long-term telemedicine development plan for the target company.

Risk management and patient safety.

Within this project, recognizing that "telemedicine is medicine", also requires considering the consequences for safety implied in the workflow, especially patient safety. The issue of patient safety is about: *"The avoidance, prevention and amelioration of adverse outcomes or injuries stemming from the process of healthcare" (Vincent, 2006:14).* Acknowledging that safety is the foremost dimension of quality of care and that the primary focus of risk management in health care should focus on patient safety (Vincent, 2001), risk management in "The Future of Telemedicine in O&G" will be strengthened by relating it to perspectives (Suchman, 2007; Rosness, et al., 2010) that expand the understanding of robust practices related to work processes and technology in use. The perspectives are based on the idea that work, including decision-making, is context-dependent (situated).

The decision support system should be designed to create and support the systematic/theoretical representation of the telemedicine workflow composed by four stages: patient monitoring, data sharing, decision making, and action. However, such a system should be designed to create and support such a workflow, but must also be flexible enough to allow for entirely different courses of work. From a safety perspective, it is important that

1. The system does not restrict the work from unfolding the way it would have done in a collocated setting even though this breaks with designed/theoretical work flow
2. There is sufficient safety margins with respect to the decisions that are made
3. There is sufficient technical and organisational resources and buffers to ensure reliability and back-up alternatives

Telemedicine prototype; “On the go”

The future work on the Telemedicine prototype “on the go” is a user driven innovation process to take the “on the go” solution to a next level. There will be executed several iterations with the medical users before final tests on the impact on the medical decision making-process and the overall healthcare service are executed. The feedback from the users through the iterations is the key for redesign and further development of the user interface and different attributes. The project will evaluate technology requirements for design (workshops/focus groups and scenario use); and implement and validate technology in use.

Acknowledgements

R. Helland, O. Hansen, ConocoPhillips; A. Pimenta, Paulo Viana, P. Da Silva, Petrobras; H. Lødøen, N. Agersnap, IBM; J.P.Johansen, B.O.Haugen, T. Haavik, NTNU; J. Dale, St.Olavs Hospital; L.Bodsberg, R.Rosness, SINTEF

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