Operations room design for the control of a fleet of robots

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Ontology-based function identification and allocation

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ABSTRACT
In this research work we focuses on the elicitation of concepts for the design of an oil and gas complex system involving a fleet of robots. We are using expertise and an experience-based approach to formalize existing control rooms and extending them to include robots. We are building a structural and functional ontology to identify and allocate current and emergent functions. The approach leads to the development of a software simulator that includes structures and functions of an oil and gas platform and its operations room.

Keywords
Oil and gas, control room, ontology, human centered design, fleet of robots.

INTRODUCTION
Offshore platform infrastructures are risk-adverse and cost-effective. This is the reason why oil and gas companies are looking for a new type of platforms. They project to developed unmanned infrastructures. In order to reach this goal, we propose a new way to operate a site remotely using a fleet of robots and specially design an operations room. Developing a fleet of robots that can take humanly-dangerous activities require a deep understanding of human activities on an offshore site. We deliberately chose a human centered design approach that dictates to identify and allocate appropriate functions among robots and human operators in the operations room. Results of this cognitive functions analysis will be used to define the specifications of the operations room. These encompass guidelines for human computer interfaces, scheduling rules for autonomous robots, workflow between the different control entities (e.g, control room, SMART room, operations room) and between robots (e.g, several robots executing a common task).

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COLLABORATIVE WORK ENVIRONMENT
Running an oil platform requires maintenance operations. Most of them involve the management of daily events. These infrastructures be seen as complex and unstable systems. Control rooms are directly implemented on site to maintain platform in good conditions. These control rooms are designed to manage operations in real time on the field (e.g coordination of day to day operational tasks).

Every operation generates a large quantity of data. The oil and gas companies collect and exploit these data. For that purpose they developed a few years ago Support and Monitoring of Assets in Real Time (SMART) rooms which aim to analyze and capitalize all the data from platform [1].

These rooms were created with the will to be a collaborative work space.

Current SMART rooms are equipped with communication tools such as screen walls, smartboards, computers. SMART rooms have been installed in different oil and gas companies' subsidiaries. The main objectives of this collaborative work environment are:

- A better prevention of critical failures which lead to important shortfalls by a closer monitoring.
- An improved planning taking into account a maximum of information and constraints
- Sharing of real time information between sites.
- Reducing the need to be on or to go to the remote sites.
- A better preparation of interventions on site which potentially reduces intervention duration.
- An improved logistic support by sharing real time information, well defined requests and a closer follow-up.

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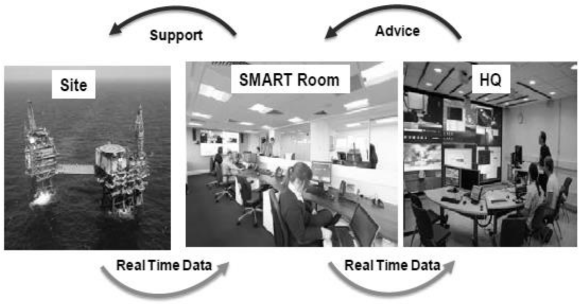

Figure 1: Relation between the different control entity in Total Eploration & Production (SMART room= tier I, HQ=tier II).

Equally collaborative work environment has been established at the headquarter to provide a tier II support to operation.

Internal reports highlight that these rooms are not used at their full potential. Ergonomics of the room has been shown to not to be always suitable to operate these rooms at their full potential. The experience shows that the occupation time is under fifty percent for the major part of the SMART rooms [1]. In this work we focus on integration of robots on the platform. This change implies the design of a new area from where robot management will be performed. This operations room will bring new kinds of workflow between the different control entities. The location of these rooms is to be determined during the study. We based our research on a taxonomy of existing collaborative work environment and the identification of a lack of functions and equipments to design the future operations room which will manage the robots on the platform. Indeed, the idea is to develop the operations room using a human centered design (HCD) approach.

METHODOLOGY

Our HCD approach is based on multi-agent modeling, cognitive functions analysis and study of the tangibility of the underlying complex systems, which includes the analysis of five properties: complexity, maturity, flexibility, stability and sustainability [2]. The methodology relies on the following steps. An analyses based on domain expert knowledge, as well as on activity analysis carried out using human-in-the-loop simulations. At each stage of the development an effective and usable solution is produced. This prototype is tested through formative evaluations. This agile approach enables the adaption of the robot's functions and potentially the infrastructure of the platform.

In this HCD approach, we start by developing software architecture and related physical and cognitive functions that will need to be tested against the five tangibility criteria. In other words, we plan on developing a simulation of the operations room and platform that need to be managed remotely. The virtual prototype will use data available from oil and gas companies existing test room and platform.

Our HCD approach is also scenario-based, starting with the development of an ontology to provide declarative scenarios defining agents and their resources, and procedural scenarios defining agents' roles and functions.

ONTOLOGY DESIGN

Infrastructures such as oil and gas platforms are complex systems that need to be more explicitly describe, since they generate a large amont of data every day. Platforms requires numerous operators performing various and complex tasks. Describing such infrastructures and their operations requires a deep understanding of the interfacing of operator's tasks, as well as underlying organizations [3].

Using an ontology to describe a platform operation will enable us to decrease ambiguity in this collaborative work.

Indeed, it will provide the design team with a shared and explicit understanding of stuctures and functions (e.g,vocabulary used, constraints) usefull for operating a platform and design its related operations room [4]. Functions are represented by their role, context of validity and resources that are necessary to accomplish them. Resources are in turn represented as system (i.e structure and function) therefore the approach is recursive. The key issues will be identification of the appropriate level of granularity and recursion that fits the purpose of the study. Consequently, key functions are defined and allocated to robots and human operators in the operations room with a special focus on cooperation rules that defined the articulation between the various functions. After several iterations we expect to have emergent functions which will have to allocate on an appropriate way to the robots or the operators. This cannot be done without domain expertise and experience. This is the reason why we are intimately working with oil and gas experts in a participatory way. We expect several iterations to reach an acceptable ontology of the domain. We expect to have an ontology to be presented at HSI 2019.

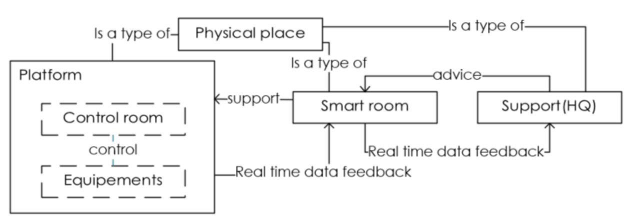

Figure 2: High level structural ontology

DISCUSSION

To gather the data, we are currently performing a literature review on what oil and gas companies are doing on the subject, and more precisely gather current models and experimental results. This research work is carried out in collaboration with an oil and gas company using an experimental platform. This review will be complemented by subject matter expert's interviews.

Then, thanks to a better knowledge of platform operations we will be able to iterate on structural and functional ontologies in order to identify and allocate functions. We are also gathering data on the different existing digital tools inside the company. We want to create the new interface based on current tools. Indeed, to be efficient the future interface has to fit with the existing tools used by the other entities of the platform such as the current human organization. This is a guideline we want to follow in order to optimize the acceptance and the support around the future interface.

Consequently, we plan on building different scenarios. The prototype will be tested using these scenarios in normal situations as well as in abnormal and emergency situations using safety, efficiency and comfort criteria.

For example, remote control and management of a fleet of robots will be tested using a simulated platform on cases like battery autonomy or communication among the various agents (e.g, robots, human operators). We believe that going from a virtual simulator to a tangible prototype build from the ontology will improve understanding on function allocations, change management and more generally definition of the various structures and functions. Here the HCD approach will enable us to take into account human factors in our future developments. We expect each iteration of the prototype to significantly improve the overall safety.

CONCLUSION

This PhD is a part of a bigger project which aim to create a new generation of unmanned platforms. This is a radical change in the way of designing and operating these infrastructures. To better understand the structure and the functions of an offshore platform we decided to build an ontology. This is the first step of this research work. Then, over the three years we intend to design an HCD based operations room to manage the fleet of robots, but also establish the cooperation rules among the different agents. Our goal is to investigate how the cooperation rules and emergent functions are key to the success of the robots' management. We intend to reach an automated planning to drive the fleet of robots. We will conduct experimentations, first on a virtual simulator and then on an experimental platform and as the robot's technology mature on real offshore platforms. Additionally, the result expected by the company is a technical specification on how to design an operations room and the interactions with other structures such as the control room and the SMART room.

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