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The Intelligent Mobile Office for IT-support on Large Onshore Plants

An ethnographic research searching for solutions that will do the process plants in the oil and gas industry more intelligent in the future

Camilla A. Linger

CHALMERS

UNIVERSITY OF GOTHENBURG

IT Universtiy of Göteborg
Chalmers University of Technology and Universtiy of Gothenburg
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ABSTRACT

The oil and gas industry is a large industry in the world and the oil and gas industry has a history, since 347 A.D. The oil and gas industry generates a lot of money and has been a reason for world conflicts. Many people associate the oil and gas industry with high risk, hazardous working environments. Plant employees receive generous remuneration because of this inherent risk. One of StatoilHydro's goals for many years is to have zero accidents and damages at their plants. Research is being carried out to towards meeting this goal, with some results already implemented. Since 2006, StatoilHydro has run a large research project in "Integrated Operation (IO)". One of the sub-projects is "wireless communication and wireless sensors" which also includes research in "intelligent environments". *"Intelligent environments"* is a quite a new and interesting concept. The purpose of this research is to explore if a process plant can be made more intelligent and how this might be accomplished?
During the investigation stage, semi standardised interviews were hold with nine persons who work with different working tasks in StatoilHydro, two seminaries were visited and participant observations were done during 8 days at Tjeldbergodden, divided in 3 periods. From this data ideas were generated. One of the ideas was of more interest to StatoilHydro, which was consequently analysed in depth. This idea was to increase the use of the cars which the operators at onshore plants use for transport. Thus, this research enters the subject of mobile ICT (Information and Communication Technologies) and will answer the questions: What will a mobile office in a car look like? How can the car as a mobile office (with mobile devices) be of assistance to the operators, especially in geographically distributed onshore well and processing facilities? How will the car as a mobile office influence the safety level at the plants? A detailed study was done for one potential use scenario, examining, how the car as mobile office might improve in the W.P (work permit) process. The result of the research was that plants can be done more intelligent using the ideas and findings which are presented in this paper. To have the possibility to implement a mobile office in cars at onshore plants, the plants first need to a get wireless network solution. A mobile office will generate lot of benefits to the operators at the plants, the greatest one will probably be time saving (less unnecessary travels). This paper will present how the research was conducted, to answer the research question *"How can a process plant be made more intelligent?"*, its results, as well as background information regarding the oil and gas industry, intelligent environments and wireless technologies.

Keywords: Oil and gas industry, intelligent environment, ubiquitous computing, wireless technology, semi standardised interview, participant observation and mobile office

Abbreviations

The following abbreviations are used in this paper:

Abbreviations	Descriptions
AI	Artificial Intelligence
ASU	Air Separation Unit
DSSS	Direct Sequence Spread Spectrum
ESV	Emergency Shut down Valve
EX	Explosion Protected
FHSS	Frequency Hopping Spread Spectrum
HART	Highway Addressable Remote Transducer
HSE	Health, Safety and Environment
ICT	Information and Communication Technologies
IO	Integrated Operation
IR camera	Infrared camera
LOS	Line of Sight
LCV	Level Control Valve
LNG	Liquid Natural Gas
LT	Level Transmitter
MAC	Media Access Controller
MTO	Man, technology and organisation
NLOS	Non Line of Sight
NTNU	Norwegian university of science and technology
PA system	Public Address System
PC	Personal Computer
PCV	Pressure Control Valve
PDA	Personal Digital Assistance
PHY	Physical Layer
PLC	Programmable Logic Controller
PSV	Pressure Safety Valve
PT	Pressure Transmitter
P&ID	Piping and Instrumentation diagram/drawing
RF	Radio Frequency
SIL	Safety Integrity Level
SIS	Safety Instrumented System
TDMA	Time Division Multiple Access
VHF	Very High Frequency
VISAS	Volvo Innovation Support Autolives Safety
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WP	Work Permit
WPAN	Wireless Personal Area Network
WSN	Wireless Sensor Network
4WD	Four-wheel drive

CONTENTS

1 INTRODUCTION

This is a master thesis in Intelligent System Design (ISD). The goal of ISD is to develop intelligent systems in order to generate and design intelligent products. The market for intelligent product is growing enormous today. Intelligent products are and will probability even in the future be developed in a lot of different markets. Examples on intelligent products can be a total automatic and self thinking vacuum cleaner, a guard robot, an algorithm that told you the shortest way to drive to a specific goal and a picture algorithm which can sort out different types of batteries. The essential point with intelligent systems is that they are able to adjust to the need of the user and can thus provide more customer and flexibility value. An environment with co-operative intelligent products can be seen as an intelligent environment. Intelligent products will generate one way to start making products more intelligent is to do them mobile, which generate the possibility to use the technology everywhere. A rather new technology, wireless, has generate the possibility to do things mobile. The mobile phone is probability the most known product which make use of wireless technology and also the first successful ubiquitous computer [14]. This thesis about intelligent environments is done in the oil and gas industry in Norway, with focus on onshore process plants. Today onshore plants in Norway lack wireless network solutions, therefore will this thesis discuss how wireless networks can support use of mobile solutions for increased intelligent environments and also safety. In the oil and gas industry in Norway all activities on all levels need to strive for high safety and low risk. One important goal for the oil and gas industry in Norway is strive for zero accidents and demands on people, animals and the nature. Therefore will this paper also discuss safety in an MTO (man, technology and the organisation) perspective.

1.1 The Purpose with the Research

The purpose of this research is to study if a process plant can be made more intelligent and in what ways? The questions are, can the technical equipments and the persons interact with each other or support each other in more intelligent ways? Can the ideas from ubiquitous computing be used to make the plant more intelligent? If the process plant can be made more intelligent, what will it look like? How will the changes affect the workers in and around the plant, the organisation and the lifecycle of all plant components.

1.2 Why an Intelligent System and Useful Methods to Develop an Intelligent System

The aim with an intelligent system is that it should be beneficial for the workers. The systems ought to be adapted to the workers, not as with old technologies which required people to adapt to the technologies. The use of user-centered design processes in design of technologies for people has increased in recent years. Primary reasons for involving users in an early phase of the process are to increase their acceptance of the products [4] and to improve their usability of the products. The most common methods for capturing user's experiences are interviews, observations, surveys, storytelling and diaries [3]. In this research, two of the methods, interviews

and observation, have been used to find out if a process plant can be made more intelligent which was later verified which potential users. The reason to use more than one method is that all research technologies generate more or less different information and this is frequently called triangulation [7].

1.3 Delimitation for This Paper

The research that generated this paper was done from February to June 2008 at StatoilHydro's office, Rotvoll, in Trondheim of the student from the master program "Intelligent System Design" at It-university in Gothenburg. The student had no earlier knowledge in the oil and gas industry. The reference plant, where the observations were done, was the onshore plant Tjeldbergodden, only two hours boat trip from Trondheim. All interviewed workers were either located at Rotvoll, Tjeldbergodden or had a connection to Rotvoll. The study generated many findings and ideas, but only one was deeper analysed. One of the ideas was found more useful by StatoilHydro and of interest for their large onshore plants. This idea was a mobile office which will fit into the cars. The operators use cars for transport at onshore plants. Deeper analysis was conducted with regard to which equipments and software should a mobile office include, the demands of the equipments in a mobile office and how a mobile office might improve MTO (Man, Technology and Organisation). The end of this paper is a concept description of a mobile office, a discussion about the benefits of a mobile office and which safety barriers a mobile office is in need of is presented.

1.4 The Aim with This Paper and its Design

The aim of this paper is to present a research done around the question *"How can a process plant be made more intelligent"*. The research done for this paper has included generation of ideas of solutions and an evolution of a concept of one of the ideas generated during the research, a mobile office. The paper is written for two groups of people, persons in the oil and gas industry and persons with knowledge in intelligent systems. Chapter 2 will present knowledge about intelligent, wireless, mobility and safety seen in an MTO perspective.
The used methods (observations and interviews) in this research are old methods which have not been common the development processes of technologies. The methods (observations and interviews) have today been more used in development processes of technologies. Therefore will chapter 3 present four successful studies of information systems which used the methods, observations and interviews. A description about how methods (observations and interviews) and how they have been used and how the concept evaluation has been done in this research are in chapter 4. Chapter 5 present facts about the oil and gas industry in an historic perspective and the onshore plant Tjeldbergodden to generate an insight about what type of environment the research have been done in. The findings and ideas generated from the observations and interviews on how to make a process plant more intelligent are presented in chapter 6. The concept suggestion of a mobile office, the benefits with a mobile office and a mobile office influence on the safety are presented in chapter 7. Chapter 8 present a discussion about the research and the result of the research. Chapter 9 present a conclusion of this paper and finally chapter 10 includes thanks to the persons who had made this research possible.

1.5 The Contribution of the Researcher

The contributions of researcher evolve around the idea of using the cars at onshore plants to more for than transport and other ideas presented in chapter 5. The researcher also contributes the design concept of a mobile office to be used by operators in the cars. Knowledge about the plants, the work at the plants and needs of the mobile office, has also been collected and analysed during semi standardised interviews and observational studies

2 THEORY

This theory chapter will present fact according to the relevant areas (intelligent technology, mobile, wireless and safety) for the concept suggestion with is presented in chapter 7.

2.1 Intelligent Environment

If a person will answer the question, what does a computer look like? The most common answer will presumably be that it has a screen, a keyboard and a mouse. If it was possible to ask the opposite question to a traditional computer (with a screen, a keyboard and a mouse), what does a person look like? The answer will presumably be that it has a hand with one finger, one eye and two ears [33]. Figure 2-1.

Figure 2-1 shows how persons and computers will describe each other.

Today and in the future the focus will presumably be more on computing than computers. Computing means the interesting connection between the computer world and our physical world. How can a computer help us communicate with other persons and how can we communicate with the computer? An interesting subject for research is, where in our environment computers can be placed for contracting an intelligent environment. The computer will presumably not look like a traditional computer instead there will be many embedded computers [33]. *"This line of research goes by a number of names – ubiquitous computing (Weiser 1991), context-aware computing (Dey et al. 2001), pervasive computing (Ark and Selker 1999), embodied interaction (Dourish 2001), and more."* [37].

An intelligent environment that supports people can be implemented in many places. Before contracting an intelligent environment studies of the persons in the environment and studies of the environment are needed to be done. These studies will generate knowledge about what kind of support from an intelligent system that can be needed in that specific environment, where are physical computing needed? *"Physical computing is about creating a conversation between the physical world and the virtual world of the computer [33]"*. The conversation from one form of energy to another form of energy can be seen as transduction, input → process →output. Examples of transduction will be given in Figure 2-2.

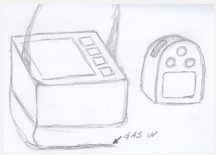
Input – Electrical voltage **Transduction** – Speaker  **Output** – Waves in the air	**Input** – Waves in the air **Transduction** – Microphone  **Output** – Electrical voltage
An example on an classic transducer	*An example on an classic transducer*
Input – Gas **Transduction** – Gas detector  **Output** - Alarm	**Input** - Waves in the air **Transduction** – Ear  **Output** – Nerve signals
An example on a transduction in the oil and gas industry	*An example on a transduction in the physical computing system*

Figure 2-2 shows different types of transductions.

The oil and gas industry has a lot of complex systems which are operating in an environment with explosive mediums. Operators in the process area of the plant are serving the systems, but the systems are controlled from a centre control room. The information from the systems and theirs devices are in the most cases sent to the control room. Safety is in focus, no people or the surroundings are allowed to be affected in any negative ways. An interesting question is: can the plant be an intelligent environment that increase the safety and decrease the cost? Below follows two examples of intelligent systems that can be used at plants, they are from researches at StatoilHydro.

"Arriving at the office" [38]
The engineers will have in-office agents (computer) which help the engineers to plan their work schedule in an optimal way. The in-office agent will be connected to the engineer's calendar and other systems that are important for the engineer. The in-office agent will also have the possibility to modify the work schedule of the engineer during the day if new unexpected conditions appear.

"Remote and on-site monitoring and control" [38]

Give the engineers the possibility to do fault searches on processes at distance from the process area of the plant. In the fault searches the engineers will have use of 3-D camera views of the processes in the plant and the values of the measurement instruments in the processes in the plant through wireless sensors. The engineers and the operator will communicate with each other with the help of video conference equipments.

The *F3 Wireless Communication and wireless sensors* project at StatoilHydro runs a subproject in intelligent environments. The goal of the intelligent environments project is to create *"an intelligent plan that support a more effective, co-operative, and safer environment"* [38]. The innovation will be in the applications which will have the wireless communication system as building blocks. [38]

When constructing an intelligent environment it is not only to mix a lot of technology in the environment. The technology needs to be smart, serve the people and other units with right information at the right time. The first movement in the history to make a total intelligent world has started with making the technology mobile, which generates the possibility to use the technology everywhere. The mobile phone has been seen as the first successful ubiquitous computer [14]. Think if your mobile phone can be automatically shut down when you enter a mobile free zone e.g. a cinema or a hall used for examinations. It would be great in most cases, but not when you wait for an important call and have dispensation to have your phone on. To make the function that knows when to turn off or not when entering a mobile free zone is harder than to make the function that always turn off the mobile when entering a mobile free zone. When do you think the environment is intelligent?

As a summery, a fully intelligent environment will not just include technologies which can offer people and other units' information etc. The technologies also need to be intelligent enough to offer the right information or act in the right time. But that do not mean that all technologies (agents) need to have same level of intelligent.

2.1.1 Components in an Artificial Intelligent (AI) System

In an intelligent environment, agents with different level of intelligence will act. Independent of the intelligent level of the agents the components of the agents are the same. Most of the agents have sensors that receive information about the environment around them and act according to that information. An easy example of an agent is a human. The sensors of a human are eyes, ears and nose etc and a human act through speaking and using their hands etc. In the start of the design of an agent, the task environment needs to be specified. The task environment includes the performance measure, the external environment, the actuators and the sensors and can be specified in a PEAS table. Table2-1 present a few examples in a PEAS table.

Table2-1 ***shown how a PEAS table can be used to specify the task environment [44, 45]***

	Performance measure	**Environment**	**Actuators**	**Sensors**
Automatic taxi driver	Safe, legal, comfortable trip, max profits	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, horn	GPS, engine, sensors, speedometer, cameras
Medical diagnosis system	Correct diagnosis	Patients, hospital, staff	Displays questions & diagnoses	Answer to comp, fen, questions
Satellite image analysis system	Correct image classification	Downlink from orbiting satellite	Display classification of objects	Colour pixel arrays
Refinery controller	Maximize purity, yield, safety	Refinery, operators	Valves, pumps, heaters, displays	Temperature, pressure, chemical sensors

A good description of an agent is: an agent can be the art of constructing programs *"that interact with precisely defined environments, so as to optimize a given, precisely defined performance measure"* [45].

Agents can act in both single-agent system and multiple-agent system. In a multiple-agent system the agents do cooperative problem solving.

To allow a system to be "Intelligent", it must at least satisfy some of the requirements [11]:

- *"Intelligent system behave logically"*
- *"Intelligent system solve complex problems"*
- *"Intelligent systems are responsive and adaptive"*
- *"Intelligent system provide nonlinear program navigation"*
- *"Intelligent system make effective use of existing information"*
- *"Intelligent system are user-friendly and highly interactive"*

2.1.2 Different Types of Intelligent Agents

The most common agent today is the table-driven agent. The table-driven agent decides how to act after a look into its tables. Theoretically this agent has no limitations [45]. But if the tables become too big it will take a lot of time to scan through the whole table. A common requirement on systems today is the execution time and in those cases a table driven-agent is not good enough.

Simple-reflex-, model-based-, goal-based-, utility-based agents are four basic types of agents, with different level of intelligent. The programs of the agents are the base in all intelligent systems and can improve their performance through learning. [44]

A simple base agent (Figure 2-3) determines its next acts only on its current prospect and can not handle any historic things, has no memory. Then decide how to act it uses

condition-action rules (if condition then action rule) and its environment need to be fully observable to generate acts [44, 45].

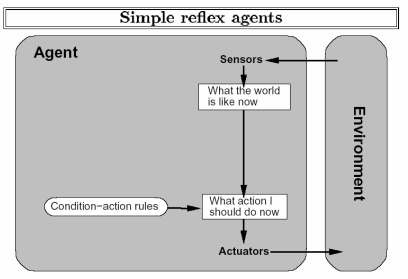


Figure 2-3 ***a simple agent [45]***

A Model-based agent (Figure 2-4) determines its next actions on three parameters its current prospect, its old (last) prospect (which is saved in memory of the agent), and its last action in using condition-action rules. In holding track of the last prospect a model-based agent can act in partially observable environments (none fully observable environment). Model-based agents have limitations as lack of flexibility and only fixed hardwired goals [44, 45].

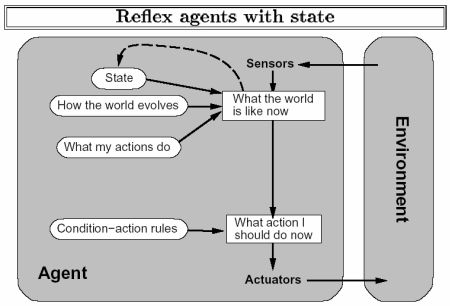


Figure 2-4 ***a model-base/Reflex agent [45]***

A Goal-based agent (Figure 2-5) remembers its last prospect in the same way as a model-based agent. But the goal-based agent rules also depend on the goal of the action. The goal can be generated as input and that increase the agent flexibility.

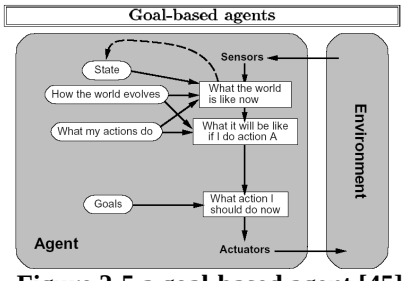


Figure 2-5 a goal-based agent [45]

A goal can in many cases be described as binary (success or not success) and the ways to reach a goal is often more than one. The different ways to reach a goal generates different levels of performance. A utility-based agent (Figure 2-6) *"maps a state (or a sequence of states) into a real number, which describes the associated degree of happiness"*. A utility-based agent with a complete specification of the utility function

can generate a rational decision in two cases when the goals are inadequate. First, when the goals are in conflict only some can be achieved (for example, speed and safety). Second, several goals that the agent can struggle for but none of them can be achieved with certainty. In those cases the agent will weighted the likelihood of success against the importance of the goal. [44]

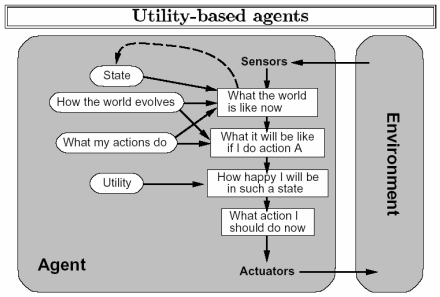


Figure 2-6 ***a utility-based agent [45]***

All types of agents can be created as learning agents. A general model of a learning agent is presented in Figure 2-7. Already in 1950 Turing realized that to actually programming an intelligent machine will be too much work. A lot of methods for making learning have been developed, some of them are: [44]

- Explanation-based learning
- Relevance-based learning
- Knowledge-based learning
- Inductive logic programming (ex. Decision tree)
- Statistical learning methods (ex. Neural network, kernel machines)
- Reinforcement learning

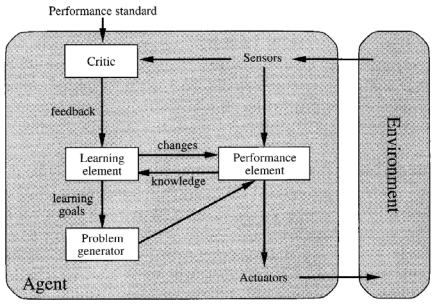


Figure 2-7 a general model of an learning agent [44]

2.2 Mobile Work

The word mobile is used together with other words to describe different things, as mobile phone, mobile organisation, mobile face, mobile worker, mobile work etc. One of the definition of mobile is *"Capable of moving or of being moved"* [56, 57]. In this paper a deeper discussion will be around the words mobile work, mobile worker and mobile office. These three words are close related to each other. A mobile worker can be described as persons who change workspace during their work, doing mobile work. This generates a need of a mobile office which *"typically include a cell phone, laptop computer and a modem to link the computer to the internet or a company's*

main office" [58]. Two technologies which have generated the possibility to do most types of office works anywhere are broadband network and wireless communication [59]. Earlier many business-people thought about mobile offices as something that was used during business travels, e.g. at trains, airports or in hotel rooms [59]. Today mobile offices are used in the daily work.

The difference between a stationary worker and a mobile worker is sometime diffuse. Even persons who have their own stationary working space in an office make movements. They walk to the printer, to the coffee machine etc [52]. There is no common way to categorize workers different levels of mobility. Kristoffersen and Ljunbergberg have introduced three archetypes, which they called wandering, travelling and visiting, to describe different types of mobility [52].

Wandering =
Workers who are in the same office all the time and walk around to help others, for example it-support workers

Travelling =
Works which take place during travels

Visiting =
When workers go to other places/buildings/countries, to do work for a few hours to a few days

Luff and Heath have categorized different levels of mobile work by identifying mobility as micro mobility, local mobility and remote mobility [52].

Micro mobility =
"is the way in which the artefact may be mobilized and manipulated for various purpose around a relatively circumscribed, or "at hand" domain"[52]

Local mobility =
"is more scatted, for instance, walking between rooms, floors and buildings at a local site, e.g. that of product designers at a conculting firm, personal on the London underground, or bank officers at a customer service center" [52]

Remote mobility =
"is when remote users interact with each other using technology e.g. construction foreman visiting work teams" [52]

"When a mobile worker goes to work they must decide where that work is going to be, under pressures of task and management" [13]. Brown, B and O'Hara, K have done a research which focus on how mobile workers have used technologies to organise and make productive of their time and location [13]. The persons they studied were all high professional mobile worker. They have divided their findings in three "areas"; place changing work, work changing place and work and time.

Place changing work: Mobile workers meets different kind of working places during their work. Different working places for sales may be in their office, at a train, in a waiting hall, in a hotel room, in a client's waiting room etc. Even if mobile workers are given the possibility to do the same work in all different places Brown, B and O'Hara, K found that the workers chose to do different working tasks in different places [13]. One of the mobile workers in Brown, B and O'Hara, K research said:

"No I think it's just those ones plus the sort of the bedside reading type material or background reading and I'll use the flight as an opportunity for doing an hour or so worth of the background reading. So you know I've saved it up for the last few days rather than doing it during the working day, I just thought I'll put it to side rather than doing it during the working day and do it on the plane. Yes, or probably extract from some of those plus stuff to read on the plane so that the last couple days the stuff that I'd sort of normally read I just sort of save it up for the journey."

Two reasons for why not start the computer and make work on it in all situations which were mentioned in Brown, B and O'Hara, K research are [13];

- lack of time, it take time to start the computer and if they just should be in that place for a couple of minutes the workers see no use in starting the computer
- no electricity in that specific place to use, this is also one of many problems with mobile work according to Lauries [13]

Work changing place: *"Mobile work does not just "take place" but rather "makes places", transforming locations as diverse as public and private transport, cafés, sites of leisure and offices"* [13]. That means mobile workers do the spaces available for them workable. The two technologies, a network connected laptop and a mobile phone have generate the possibility to make places almost everywhere workable. A network connected laptop generates the possibility to do works and a mobile phone the possibility to speak to colleges, clients etc. Even if the places that generate the possibility to use laptops increase, Brown, B and O'Hara, K found that one of the most important technologies for mobile workers still are papers, a paper can easy be printed and carried. Luff and Heath [13] have pointed out, that documents in paper format have *"a number of critical interactional properties such as the ability to scribble in the margins, pass around a room, photocopy and so on"*.

Work and time: When workers are mobile their need of arranging meetings, to be able to regularly meet others, increase. The mobile workers need to find a balance between working, travelling etc [13]. An example on a technology which is used to arrange meetings is Microsoft Outlook [52].

Face-to-face meetings are still important even when new types of technologies for communication appear. Informal face-to-face meetings or spontaneous interactions generate an easy way to exchange of useful information [52]. Mobility both increases and decreases the possibility for informal face-to-face meetings. Workers with wandering character of mobility have the possibility to have informal face-to-face meetings with the colleges they meet during their walk in the office building. Persons who travel a lot in their work have les possibility to have informal face-to-face

meeting with their colleges in the office, but increase possibility to have informal face-to-face meeting with people they meet during their travels.

Today new types of technologies for communication appear all the time. Today people can make use of phone call, sms, e-mail, instance message, video conference etc to communicate with each other. *"Many studies have shown that users delevop norms for how, when and for what purpose to use new information and communication technology [50]"*. Weilenmann, A has done a study on a prototype called Hummingbird among ski instructors [50]. When the ski instructors became close to each other in the ski slopes, the Hummingbird indicated that. Weilenmann, A also referred to Dorish et al. research in her paper. Dorish et al. research has shown *"that the users (in this case the authors) adapted to the technology and learned the most effective way to use the system"*. One interesting thing in Weilenmann, A research around the Hummingbird was that she did not said how the ski instructions should make use of the Hummingbirds. This generated that it become a lot of discussion among the ski instructors about how and when to use the Hummingbirds.

2.2.1 Wireless Technology

The use of wireless technology has increased and will probability increase more in the future. As Paula Doyle said during the wireless seminar (chapter 4.3.2), wireless is the future of intelligent environment. In this paper will two "types" of network be presented, wireless internet network and wireless sensor network.

The most common WLANs belong to the standard family IEEE 802.11, which is written and used for short range communication [40]. The range in communication limits the use areas of WLAN. The first standard in the standard family IEEE 802.11 was written in 1997 and new standards in the family are still written [40]. WLAN operates in the two free frequency bands, 2.4 GHz and 5 GHz [40] and can use the frequency bands in two different ways, FHSS (Frequency Hopping Spread Spectrum) and DSSS (Direct Sequence Spread Spectrum). FHSS is *"transmitting on one frequency for a certain time, then randomly jumping to another, and transmitting again[27]"* and in DSSS *"a RF carrier and pseudo-random pulse train are mixed to make a noise like wide-band signal [27]"*. WLAN network has increased fast since the late 1990's in houses and offices. The market for WLAN made for hazardous areas is still small [40].

WiMAX is developed of the WiMAX forum and belong to the standard IEEE 802.16 [49]. The first version of WiMAX was developed in 2001. The mobile version of WiMAX was developed in the second version of WiMAX in 2005. WiMAX is a computer communication solution which can be used in both point-to-point and point-to-points applications. The advantage with WiMAX is that it will generate high bandwidth over large distances. The hope is that it should work even in environments where todays wireless technologies do not work of different reason e.g. topology. At Intel the idea is to start sell PC-cards and USB dongles with WiMAX in 2008 and 2009. Intel will also start integrate WiFi+WiMAX in laptops during 2008 [5].

Today there are three industrial standards of WSN which use the standard IEEE 802.15.4, ZigBee PRO, WirelessHART and ISA 100.11a [40]. A time axis in the history of WSN is presented in Figure 2-9. IEEE 802.15.4 is the standard that "*defined the protocol and compatible interconnection for data communication devices using low-data-rate, low-power and low-complexity short-range radio frequency (RF) transmissions in a wireless personal area network (WPAN)*" [26]. IEEE 802.15.4 describes the two lowest layers in the WSN stack, layer PHY (physical layer) and MAC (media access controller). Figure 2-8, shows the layers in the WSN stack and how ZigBee, Wireless and ISA 100.11 use them.

<table>
<tr><td>User Defined</td><td colspan="2">APPLICATION/PROFILES</td><td>User Defined</td></tr>
<tr><td rowspan="2">ZigBee</td><td colspan="2">APPLICATION FRAMEWORK</td><td rowspan="2">WirelessHART
ISA 100.11</td></tr>
<tr><td colspan="2">NETWORK/SECURITY LAYERS</td></tr>
<tr><td rowspan="2">IEEE 802.15.4</td><td>MAC LAYER</td><td>Modified MAC LAYER</td><td rowspan="2">WirelessHART
ISA 100.11</td></tr>
<tr><td colspan="2">PHY LAYER</td></tr>
<tr><td></td><td colspan="2"></td><td>IEEE 802.15.4</td></tr>
</table>

Figure 2-8 *shows how the different layers in the WSN stack are used of ZigBee, WirelessHART and ISA 100.11.*

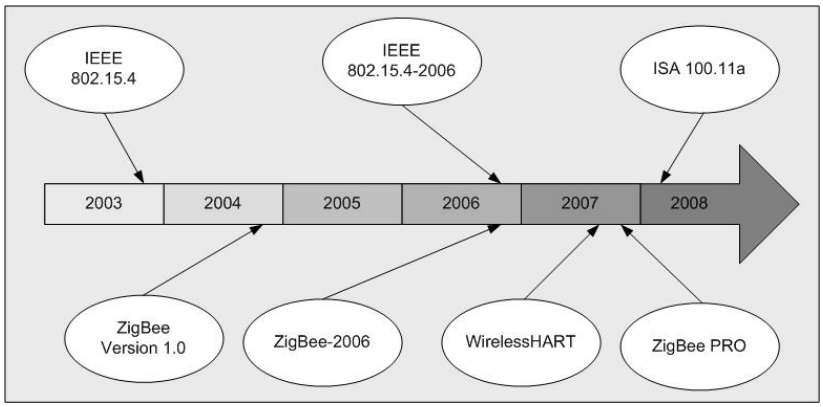


Figure 2-9 present a time axis over when the different wireless standards have ented the market

The ZigBee is developed by the ZigBee Alliance as a system that follows the standard IEEE 802.15.4 and uses the standard's layers PHY and MAC, (Figure 2-8). The network layer in ZigBee supports three network topologies (starts, mesh and cluster tree) and possible use areas are home automation, interactive toys, wireless sensors etc [17]. The first specification was released in 2004 and the followed up release was released in 2006 and included the changes in IEEE 802.15.4. Some changes were *"scalability and performance issues in large network due to nonoptimal addressing schema"* [41]. Two disadvantages with ZigBee are that it uses static channel and not enough robust for being use in industrial applications with harsh RF environments [39].

ZigBee Alliance released ZigBee Pro in October 2007 with deal with the disadvantages of Zigbee and is made for the industry market. ZigBee PRO *"offers*

enhanced security features, a stochastic addressing scheme which enables networks to change channels when faced with noise and interference" [40].

WirelessHART is developed by the HART Communication Foundation and send HART (Highway Addressable Remote Transducer) message wireless. WirelessHART was released in September 2007 as the first open communication standard designed for the industry market. WirelessHART uses IEEE 802.15.4's PHY layer and a modified version of the MAC layer, (Figure 2-8), and support multi-hop mesh topology. When communication WirelessHART uses frequency hopping and TDMA (Time Division Multiple Access) [15, 40, 41].

ISA 100.11a will be the first standard released in the ISA 100 family in year 2008 by the ISA 100 standard committee. The committee aim is to release a standard of a wireless system for the process industry with focuses on alerting, monitoring and control [28]. ISA 100.11a will use IEEE 802.15.4's PHY layer and a modified version of the MAC layer, (Figure 2-8), support cluster topology and use frequency hopping. ISA 100 standard committee informed in October 2007 that they in Release 1 will try to accommodate WirelessHART in the ISA 100.11a through a dual-gateway architecture and plan to do a more integrated approach in Release 2 [15].

2.3 Wireless Sensors

Wireless sensors are sensors that send their information wireless. A wireless sensor can roughly be divided into three units, the sensing-, the processing- and the communication unit, (Figure 2-10). Another version can be that two or more sensing units are connecting to one processing- and communication unit with wires. In addition to the three units (sensing-, processing- and communication units) wireless sensors have power supply, memory (RAM) and storage (flash). [40]

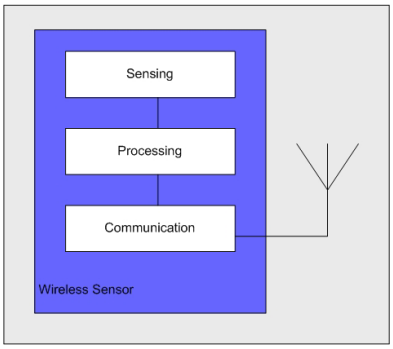


Figure 2-10 ***a simplified sketch of a wireless sensor***

The wireless sensors do the same as sensors with wire, measure the physical phenomenon and converts the values from an analogue- to a digital signal by an A/D converter. The processing unit normally analyse and processes the data from the physical phenomenon. The processing unit also *"handles the network protocol and controls the local RF transceiver"* [40]. The communication unit which consist of a RF transceiver and an antenna provides the wireless interface.

A wireless sensor has limited resource in processing capacity, available memory, storage space due and strict low-power requirement. StatoilHydro's requirement on the battery time is 5 years. In addition to the limitations a wireless sensor need to be robust, send message safe and *"to execute software implementations of complex networking algorithms with real-time requirements"*[40]. One way of sending messages safer are to encrypt them. The oil and gas industry is a rough environment so the WSN network needs to have the possibility to make self-healing and self-configuration to offer a robust and multi-hop network. One solution for generating a robust system is to use dynamic routing protocols. When using dynamic routing protocols each sensor update and save information about their neighbour sensors frequently and take care of network request from other wireless sensors. [40]

2.4 Safety (MTO)

Safety is today discussed in many different areas. Which type of safety that is discussed depends on the area. When talking about production lines with a lot of robots, machine safety is discussed. When talking about persons, person safety is discussed. In this paper is safety discussed in the MTO perspective.

MTO (*"Man, technology and the organisation")* is the idea that these three parameters will influence on the safety and risk level. According to Carl Rollenhagen the concept MTO is not new, seen from a research perspective [42]. He wrote that the industry has neglected the M&O (*"man & organisation"*) influence on the risk and safety. In the same article (from 2000) Carl Rollenhagen wrote that the trend of using MTO have started in the industries as nuclear plant, offshore, transport and medical safety, and more industries have shown interest for the concept MTO.

When designing new concepts, technologies, organisation structures etc it is necessary to analyse how it will adapt to MTO. The idea with MTO is to move the focus in the processes. For example in the development process moves the focus from only the technology part to a wider spectrum. Today it is important to understand the interaction and the integration between the man, the technology and the organisation, and how the new idea will fit from the views of all three [2] and to generate a high safety level with low risks. It is not only the factors inside the organisation that affect the safety. Many factors outside can affect the safety both in positive and negative ways. Outside factors can be legal systems, political decisions, deregulation of markets etc [42]. MTO is close related to the concept IO, which is presented in chapter 2.3.

Introducing of MTO may results in that the safety focus will be moved, from the traditional way to look on safety to a concept called resilience engineering [22]. The concept of resilience engineering is still a discussed subject and has not been broadly accepted of industry. Resilience engineering can be defined as: *"The ability of a system to go back to a new safety equilibrium state after being exposed to external perturbation [23] "*. (This paper will not go deeper into the concept Resilience engineering)

In the traditional way of looking at safety and risk, the technology is studied. If the technology was a system it was common to divide it into subsystems and study them one by one. Technology is built of humans and the humans know how it works. That did the technology predictable and made the possibility for a machine to do the assignment perfect. Event Tree and Fault tree are traditionally methods to use for designing technologies which will have high safety level and low risks. [22]

In resilience engineering the total system including technology, humans and organisation need to be robust with a high level of safety and low level of risk. The fact that technology and human do not have the same qualities does it much more complicated to construct a system with high safety level. As mentioned before, machines can make its assignment perfect. In contrast, humans are unpredictable in their way of doing assignments, but they are flexible and can do many assignments well. [22]

3 RELATED WORK

Observations and interviews have been used in developing information systems in many different ways by different researchers. Below I will give short descriptions to generate information about how three different researchers have made use of interviews and observations. These three researchers are chosen as related work because they in conformity with this theis did research about the environment and how the people in it have the possibility to either, make the environment more intelligent with sensors, decrease risks or adapt new technical application to the people who will have use of it.

Brooke and Burrell [9] have designed a sensor network in a vineyard and used ethnographic methods because they "*believed better computing solution can be arrived at by being user-centric*". They used semi standardised interviews in order to have the possibility to add questions to the questioner during the interview. They used the interviews' results to develop the system. But they also supplemented the interviews with participant-observations, when ever they worked in the vineyard. Their result became a successful prototype system for a small vineyard.

Cohen et al. [16] have used observations and semi standardised interviews for characterisation the cognitive mechanisms underlying errors in the psychiatric emergency department (PDA). They start with unobtrusive observations in order not to interfere in the process of care. The observations were done by a researcher who used to be a physician and he did each observation during three hours. After each observation the key concepts and observations were extracted from the field-notes. The results from the observations generated the questions for the semi standardised interviews. Then an intermediate model was designed and became a base for next observations.

Arhippainen and Tähti [3] have defined how user experience can be used in development of new mobile applications. They did two evaluations on the prototype (a PDA), with different test persons, both PDA users and non PDA users, in different environments. The first evaluation was divided into three phases, interview – observation –interview, and it took 20-30 minutes. The test person had the prototype with him/her all the time. During the observation the test person followed a pre-defined scenario and the interview questions for the interview were developed after a literature study. They learned from the first evaluation and did a few changes before the second one, for example, reworked the questions (became easier to understand), videotaped everything and added a new phase. The new phase was that a questionnaire and user instructions were sent to the test persons a few days later, to generate more information. Arhippainen and Tähti did not specify which type of interview they used with a name. But related to the names that are used in this paper, they did semi standard interviews.

4 METHODOLOGY

When developing technology which will generate an intelligent environment it is important that the technology is designed for the persons who will use it in that specific environment. It is common with gab between the users and the designer about what is needed to be developed. The designers develop what they believe is needed and the users may have another picture of their needs. To decrease the gap between the developers and the users ethnographic studies are becoming more common to use both before the start of the develop process, to learn about the needs, and during the develop process, to get a felling of if the develop process will generate a useful result for the users [14].

The research presented in this paper started with literature studies, semi standardised interviews and participant observations to learn about the oil and gas industry and to found out areas where more intelligent systems should be implemented. More about how these methods have been used will follow in this chapter and a time axel over when the different methods are used is presented in Table 4-1. The idée was to start to look in a wide perspective to have the possibility to search for places where an intelligent system could fit in, in a process plant and later narrow in the research, to generate a concept suggestion. During the research the idea of using the cars to generate an intelligent environment appeared. How the research start wide and later slimed in to generate a concept suggestion is visually shown in Figure 4-1. The 28th of April it was decided during a telephone meeting between the student (researcher) and her mentors, both from it-university and from StatoilHydro, that the possibility of designing a mobile office in the cars will be deeper analysed. In the end of the research a concept suggestion over the mobile office became presented in chapter 7. The findings and ideas generated through the used methods are presented in chapter 6.

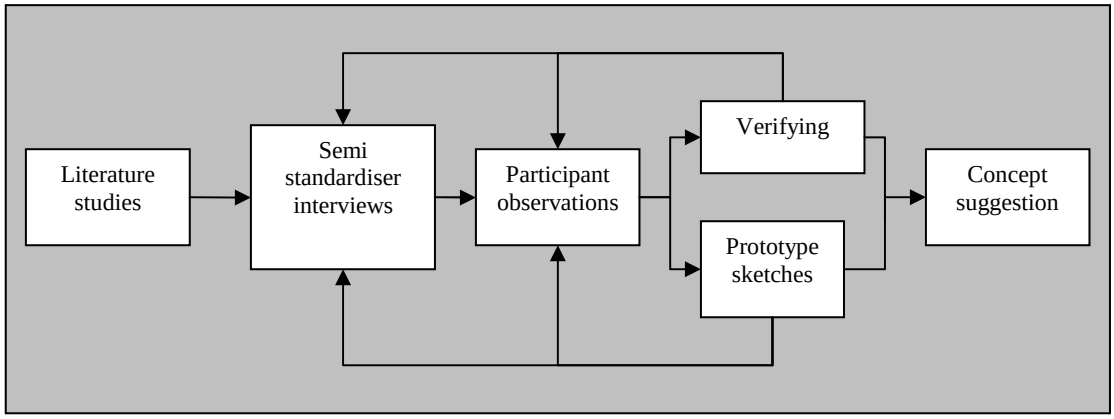


Figure 4-1 shows a flow-map over the research which has generated this paper

Table 4-1 presents a time axel above in which order the different methods have been used.

Literature study	4.1							
Semi standardised interviews			4.2.1			4.2.2	4.2.3	
Participate observations		4.3.1	4.3.2	4.3.3	4.3.4		4.3.5	
Concept development	Concept ideas have been generated during the whole research							4.4

4.1 Literature Study

The literature study has been done to get insight in different subjects, which are of interest for the research as background knowledge. The result of the literature study is presented as chapter 2 and chapter 5. The literature study was quite extensive of the reason that one goal with the research was to find ways to do process plants more intelligent and the needed technologies for the end concept was not known in the start of the research and the researcher does not know the oil and gas industry before doing this research. The literature study has included reading books (most course books from University), articles (both written by workers at StatoilHydro and retrieved from article databases at Internet), Tjeldbergodden's small pocket books [46, 47], StatoilHydro's projects "up to date documents", power point presentations (from StatoilHydro, the it-university and found on the Internet) and other relevant material which have generated knowledge in subjects, which was relevant for the research.

4.2 The Method, Interviews

How to name various interview structures differs in different sources (formal and informal, structured and unstructured or standardised, semi standardised and unstandardised etc). This paper will name various interview structured as standardised, semi standardised and unstandardised. Characteristic things for these three types are presented in Table 4-2.

Table 4-2 mention characteristic things for differ interview structures [7, 11, 29]

Structure	Characteristics
Standardised	o Asking only all the pre-done questions in the questionnaire o Common to start with more open questions and conclude with more closed o Similar to a questionnaire o The interviewer does not answer or clarify any question o Easy to do an statistical comparison on the result o The interviewer must be really conversant in the subject to prepare the right questions o The interviewer needs to think out what answers the question will generate in advance
Semi standardised	o Use an interview-guide o Common to start with more open questions and conclude with more closed o The interviewee's answer/answers can generate new questions to ask for the interviewer o Questions can be added o Important areas must be covered in the interview o The interviewer is allowed to answer and clarify questions o Can give the interviewer new knowledge o Hard to compare interviews result afterward
Unstandardised	o Does not prepare any questions in advance o The interviewer is allowed to answer or clarify questions o Frequently a part of an observation, the interviewer does not know what will happen in advance o Generate new knowledge to the interviewer o Generate a lot of data that is hard to analyse o Easy to spend time on none relevant issues

Interviews can be done either individually or in group. An individual interview is more time consuming than a group interview. Group interview is a quick and convenient way to simultaneously collect data from several persons [7]. In the group interview the interviewees give the opportunity to reflect on each other's experience [53]. But in a group interview a dominate person can overpower and steer the group options, the interviewer needs to be active in order to prevent this [7]. Group interviews generate the group's options and individual interviews generate the individual's options [7].

Two of semi standardised- and unstandardised interview advantages are:

- It generates information about the interviewee's background, experience, expectation etc. and the interviewer can ask for motivations [3, 12] to get a better understanding
- The interview situation can be more like a normal talk [3, 7]

In this research has Semi standardised interviews been used. The reason for using semi standardised interview was that it gave the interviewer the possibility to in advance prepare a few questions and think through the goals with the interview. It also generate the possibility for the interviewer to ask new questions which came up during the interview, which is great advantage in this research because the interviews are done to generate more and new knowledge about the plants and the work at the plants in the oil and gas industry.

When one of the delimitations in the research was that only one plant, Tjeldbergodden, was visited and studied. The interviews gave the researcher the opportunity to collect information about other plants than Tjeldbergodden, to have the possibility to learn about differences and likeness around difference plants. The interviewees have been chosen so they have difference work tasks, experience from different plants (both offshore and onshore) and easy to reach, most of them worked at Rotvoll or Tjeldbergodden.

Short descriptions related to the interviews are presented below.

4.2.1 Interviews Round One

The purpose with the interviews in round one was to get a first knowledge about the works and routines at plants, and knowledge and understanding of plants in general. The two interviewed persons are located onshore, but are doing works at offshore plants a lot and have been in the oil and gas industry for over 20 years. The interview with the first person was held in a small conference room at Rotvoll. The interview with the second person was held as a telephone interview. The interviews were semi standardised interviews with an interview schedule, which can be read in Appendix 1. The interviews were recorded on a computer for later analysis.

When analysis the interviews, the interview records were played several times and short notes were taken. The notes were later rewritten to summaries. The summaries of these two interviews are not included in the public version of this paper. The results of these interviews became a ground for future interviews and observations. With width basic knowledge it is easier to focus on a specific “problem” on later in the research.

4.2.2 Interviews Round Two

The goals with the second interview round were to:

- bind together the knowledge (from first interview round and the participate observation during the first visit at Tjeldbergodden) about how process plants works, including differences and likenesses
- get an complete overall knowledge of the work at a plant before doing the second visit at Tjeldbergodden (be really good prepared)

The questions for these interviews were designed after a study of the already collected materials. At the same time, points of interrogation direct connected to Tjeldbergodden were collected.

The three persons to interview were found in the office at Rotvoll. The persons have worked at different process plants (two onshore and one offshore). The idea with interview persons with experience from differences plants was to have the possibility to collect information about differences and likenesses about differences plants.

Of the reason that Tjeldbergodden is the reference plant in this research, one of the interviewed persons has experience from Tjeldbergodden.

The questions for these semi standardised interviews are in Appendix 4. The summaries were generated in the same way as in interview round one (chapter 4.2.1). The summaries are not included in the public version of this paper.

4.2.3 Interviews During the Second Visit at Tjeldbergodden

During the second visit at Tjeldbergodden most of the time was spent on doing participant observations. Before the visit, 4 interviews were timetabled in the calendar. Two of the interviews were with persons who have worked as operators at plants including Tjeldbergodden earlier in their carrier and the other two interviews were with process engineers.

The idea with the interviews were to get information about the interviewees' work, what they worked with, how they move around at Tjeldbergodden, what their work in the process look like, what type of technologies they use in their work in the process and in their daily work and get feedback on the idea with the car. A few questions were made in advance and the first part of the interviews was a talk about the interviewee's work and things around the work at Tjeldbergodden. In the second part the idea with the car was presented for the interviewee and it became a discussion about the idea with the car. The sketches in Figure 4-2 and Figure 4-3 were used of the interviewer to describe the idea with the car for the interviewees.

These interviews generate knowledge about the work processes at differences parts of the organisation, knowledge about how all signals from the process enter the control room's monitors and the interviewer got tips about things that can be good to participate in during the visit.

The interviews were recorded and later transcribed to summaries in the same way as the other interviews (chapter 4.2.1 and 4.2.2). The summaries are not included in the public version of this paper.

4.3 The Method Observation

Observation is an old method where the observer can participate in different levels [51]:

1. Actively take part in the activity during the observation
2. Be passive and only observe the activity

For describing these two ways (1 and 2) the term *"Participant-observation"* is frequently used [18].

3. Become invisible for the person/persons being observed

Buchenau and Fulton Sari [3] have developed a method they called *"Experience Prototyping"*, which is similar to *"stand-in"* [14].

4. Stand-in, the observers experience by themselves instead of observing an other person/persons using the technology [3, 14]

Which level of participant is chosen depends on the research and the researcher. There are a lot of things to take into account in order to decide how to perform the observation, for example:

- What is right ethically [7]
- How to influence on the observed person's/persons' behaviour as little as possible [18]

The observations in this research are done as participant observations. The observations have been done in participate on seminars, participate in meeting (listen and taking notes) and follow with the operators in their daily work both in the process and in the control room (seen what they did and asked why and how).

One important advantage with observations is that they generate knowledge about things that the user does without knowing and knowledge about things that are hard to explain in words [3, 14]. This advantage with observations generated a lot of ideas to this research. The operators did or talked about things without knowing that these things later became ideas and findings in this research.

Descriptions over the done observations are presented below.

4.3.1 WiMAX Seminar in Oslo

In February Tekna has a two days WiMAX seminar "*WiMAX seminar – fremtiden er trådløs*" in Oslo. Tekna's idea with the seminar was to generate basic knowledge about the technology of WiMAX, terminals for WiMAX, examples on use areas for WiMAX and information about the coming standard for WiMAX. Participating at the seminar generated knowledge about the WiMAX, the problem with Wireless (for example the problem with coverage), the stature of frequencies both in Norway and

Global and information about businesses which had done researches with WiMAX. During the seminar notes were taken and after access to all power-point presentation was generated on Tekna's homepage [21]. After the seminar one of the speaking persons was e-mailed for more information.

4.3.2 Seminar about Wireless Technology in Trondheim

"*Næringsforeningen i Trondheim*" and "*Trådløs Framtid*" has an evening seminar at Rotvoll. The seminar was about wireless in the future for oil and gas industry, the history of wireless, intelligent environment, wireless protocol and frequency band and RFID at "*Norske Skog*". Most of the information was already know, of the researcher that generated this research, from the literature study of documents at StatoilHydro. Most of the speakers are in the TAIL IO project, but a few examples on use areas were new and generate new ideas to this research. Sometime it is good to hear information that has been read because it can generate other views of the subjects. A follow-up chat was done with one of the speaker (Maria Vatshaug Ottermo) to get a deeper understanding of the goals with mobility in F5 project of TAIL IO.

4.3.3 Sintef Robot at NTNU, Trondheim

At Sintef a research project are studying the possibility if robots can replace the operators in the processes at platforms. Today there are no robots in the processes in the oil and gas industry. The robots will be controlled of operators either at another part of the pant or from a plant at another position in the world. The plan is to install the first robot at a platform in the North Sea 2015. Erik Kyrkjebø at Sintef spent time to show and demonstrate the robot for around a half hour. It was an interesting visit which presented another view of what a plant can look like in the future. Instead of add smart device to the operators in the process plants, the operators will be moved away to control the processes with assistance from robots. A presentation about how the robot may work is presented in Appendix 2.

4.3.4 The first Visit at Tjeldbergodden (One Day Visit)

The first visit at Tjeldbergodden was over one day, 10:30 am – 05:30 pm. It takes 2 hours with boat from Trondheim to Tjeldbergodden/Kjørsvikbugen. During this visit an introduction to the process plant and the organisation was generated. With the overview information and with other collected information, it was possible to do a good preparation for the next visit. Practical planning as asking to join the shift, found persons to interview etc were done during this visit. To get access to the process plant a safety course was needed to pass. This course was done during this visit. During this visit field notes was taken in an A5 book. After the visit a summary of the visit was written in Microsoft Word, this summary is not included in the public version of this paper.

4.3.5 The Second Visit at Tjeldbergodden (Three Days Visit)

The second visit at Tjeldbergodden lasted over three days. Arrived with the boat at Kørsviksbugen at 10:05, and took the boat home at 17:40 the last day. During the visit four semi standardised interviews (more about them in chapter 4.2.3), participate in two meetings (the plant meeting and the contribution meeting, with the process engineers), participate in the evenings shift works (15:45 – 22:45) were done. In the mine time the researcher was walking around in the administration building to observe actions and talking to workers at Tjeldbergodden[1].

One goal with this visit was to find places in the process, where a more "intelligent system" could be needed. One idea from the first visit was, why not use the car for more then transport? This idea generated the second goal for this visit, which was to verify the idea of using the cars for more than transport with the workers at Tjeldbergodden.

Sketches were drawn, to have the possibility to easier verify the idea of using the cars in more intelligent ways, before the second visit. Two of the sketches were frequently used in the communications with the workers at Tjeldbergodden. These two sketches are in Figure 4-2 and Figure 4-3.

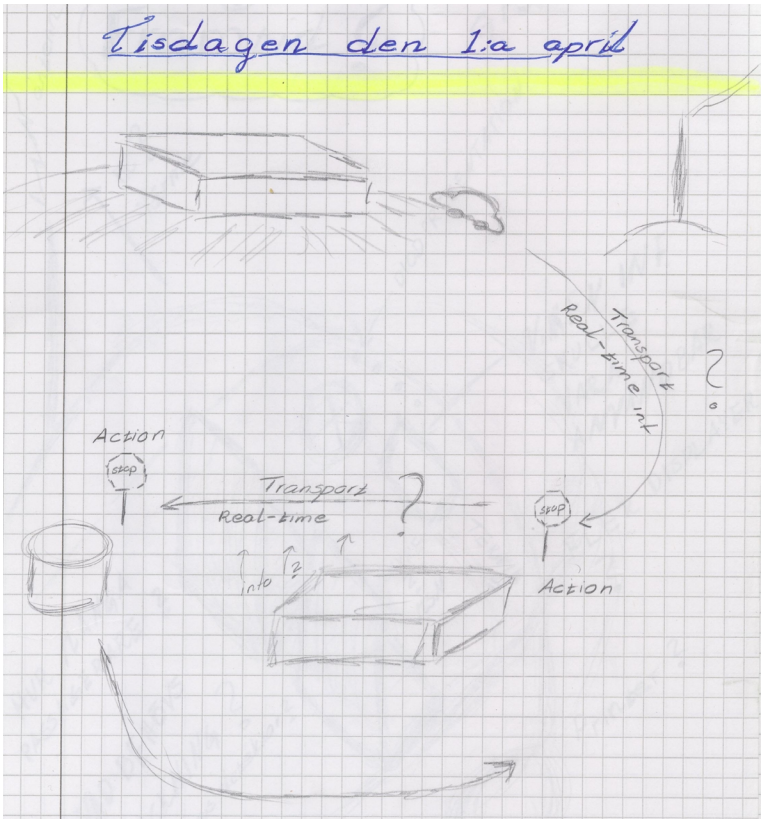


Figure 4-2 this picture was used to describe how the cars are used for driving around at the plant

[1] All workers at Tjeldbergodden are located in the administration building and are only travel to the process for doing work where.

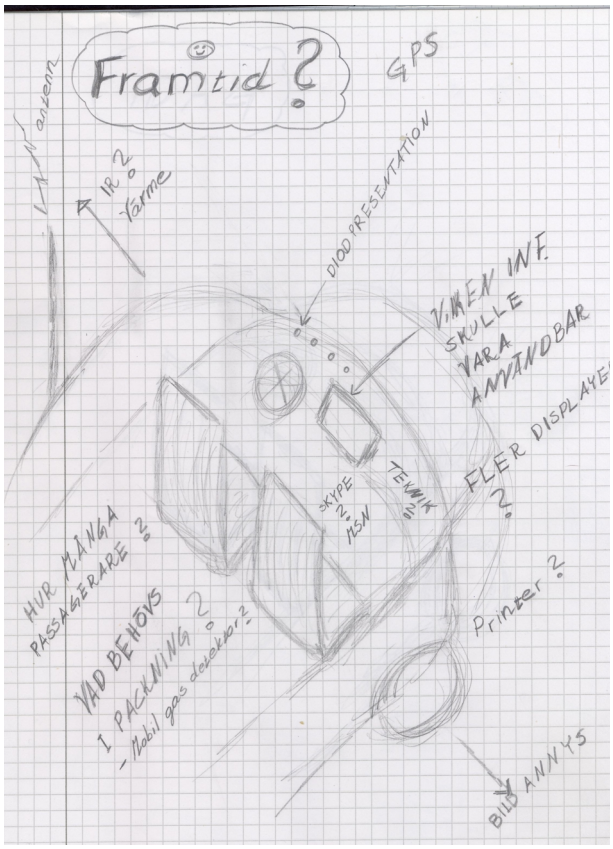


Figure 4-3 a future picture on things that can be in the cars in the future

4.4 Concept Development

The idea which was chosen to do a deeper analysis of in a telephone meeting the 28 April between the student and her four mentors, was the idea of having a mobile office in the cars at onshore plants. The cars are not EX certified and the equipments "fixed[2]" installed in the cars do not need to be EX certified, because the cars are driving at roads outside the graphical EX zones, but still in the plant. In most cases are the whole plants seen as an EX zone. The main questions in this design process to generate a concept solution (no physical prototype) are:

What can a mobile office in a car look like?
What can the mobile office be used to?
Which benefit does a mobile office bring to the workers, who will use it?

When starting to work which the design of the concept a lot of sub questions appear:

1. *Which technical components will a mobile office include?*
2. *Which size is optimal that the computer monitor has?(4, 7, 8.9 9, 10.4, 10.6, 11, 11.1 12 12.1 12.2 inches)*
3. *Which paper size should the printer has possibility to print at, A4, A3 or both A4 and A3?*

[2] With fixed means that the non EX certified technologies in the cars need to be lock in a way so the operators not gives the possibility to easy carry the technologies out from the cars.

4. *What demands will it be on the computer in the mobile office?*
5. *How to generate power to the mobile office?*
6. *If it should be possible to move the mobile office between cars, what kind of safety barriers should interfere the operator to bring the mobile office into the EX zones?*
7. *Which type of wireless solution should be used?*
8. *Which demands on size and weight will it be on the mobile office?*
9. *How and where should the mobile office be placed in the car?*

One of the goals in the design of technologies according to ubiquities computing is to do the technology adapted to the persons who will use technology and do the technology user friendly. Today the operators need to travel to their offices, which mobile offices the technologies are moved to the worker. To get knowledge about what type of design the mobile office should have to be as useful as possible for the operators a third visit at Tjeldbergodden was done during 4 days. During this visit four "pictures" with text were used (Figure 4-4) to ask the operators about, where in the cars the mobile office should be placed to be most useful and user friendly, the size of the monitor on the computer/laptop, paper sizes in the printer, may msn be used to increase the possibility to communicate (today only radio is used as communication medium in the process) etc. During this visit also external operators (3 operators from Reinertsen located at Tjeldbergodden, for doing service in the process) and several operators from the workshop were interviewed about their work and asked for comments about the idea of a mobile office. The researcher also participated in the evening shift's work and verified the mobile office on the operators in the shifts. To have the possibility to develop which benefits a mobile office would generate in the process with a W.P. (work permit), was the W.P. process studied in detail. Several of the cars which are used in the process were photographed with a digital camera to get a feeling of the space in the difference type of cars.

Figure 4-4 these four "pictures" were in the conversations with the operators at Tjeldbergodden to evaluate the idea of a mobile office

As a result of this paper a concept suggestion (chapter 6) became generated with help of innovative thinking from the researcher, the result (chapter 5.3) from the third visit at Tjeldbergodden and some research about how others have solved similar problems.

5 THE SETTINGS: STATOILHYDRO

During 70's the oil and gas industry started to grow in Norway, according to StatoilHydro. The process of spread oil and gas production generates hazard and complex environments. At an offshore platform the space is limited and the processes are divided on several different floors in the platform, in contrast is onshore plants spreed out with large distance between the different production sections. At both offshore and onshore plant more intelligent and safety solutions are wanted. Increase the safety and decrease the risk are always important goals in all part of the oil and gas industry. This chapter will present facts about the oil and gas industry in an historic perspective and Tjeldbergodden the reference plant in this research.

5.1 The Oil and Gas Industry in a Historic Perspective

The traditional oil and gas production in the North Sea were done on offshore production facilities. Today's offshore production platforms can be classified as five types (compliant towers, semi-submersible platforms, jack-up platforms, tension-leg platform and SPAR platforms), some are moored direct into the seabed and other are more temporary moored into the seabed. Even ships and land-based plants can work as production platforms. Independent of the type of production platforms, the task is the same, produce oil and/or gas. A production platform makes up of four parts, well head-, process-, help systems and living quarter. [6]

The traditional way of building and use offshore platforms in the North Sea is over, today and in the future more subsea installations will be used. When use subsea, technology is placed on the seabed, how great parts of the technology which will be on the seabed depend on the installation. The idea is to transport the stream from the wells or oil and gas to existing offshore platform or to an onshore platform. [6]. Figure 5-1 describes different ways of how to take oil and gas from the field in the North Sea. Oil has also been found under ground at different places around the world. At these places the oil plants are and will be placed direct onshore.

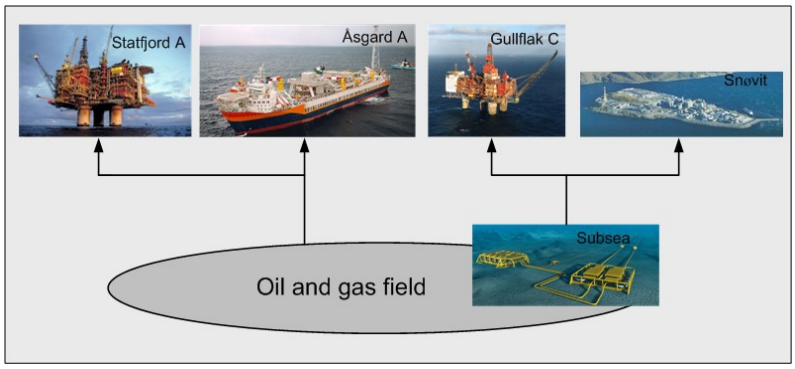


Figure 5-1 ***a general picture on the different ways to take oil and gas from an oil and gas field in the North Sea***

From the production platforms in North Sea, which separate out the oil and gas from the well stream, the oil is transported with ships and the gas commonly transported in pipelines to refineries in the north Europe. [6]

In the production process many separations are done. For doing the separations different technologies are used and many measurements need to be made to generate a good quality of oil or gas in a safe way. A short presentation of the production process is presented below.

Each platform serves normally 30-50 drillings and each drilling has its own throttle valve. It is important to regulate the throttle valve optimal for generate an optimal exploitation of the reservoir. The oil and gas company will earn as much money as possible so to optimal production is important. If the throttle valve is too open it will generate a too fast drainage of the reservoir, the pressure of reservoir will decrease faster and the total production will become lower. After all the well streams have passed its own throttle valves they will flow in the same pipeline to the platform. [6]

The stream from the drilling consists of oil, gas, water, particles, sediment etc.
In the process system a separation of the different mediums in the stream will be done. A complete separation is hard to do, but that is the goal. The oil and gas will later be transported to refineries, by ships or via pipelines, and the water will be transported back into the ocean. The first rough separation process uses the fact that the tree different mediums (water, oil and gas) have different density. The rough separation process will follows of different separation processes for the three different mediums (oil, gas and water). The whole process is different at different platforms.

In the rough separation process it is important to have the right pressure, if the pressure should be too high a pressure safety valve (PSV) will open. When the PSV opens the Emergency Shut down Valve (ESV) will stop the process. To regulate the level of oil, gas and waters in the process level transmitters (LT) are used. It is important to have the right level of oil, gas and water in the process to avoid that wrong medium stream into a pipe of another medium. A synoptic sketch of the separation at Nedregaard is presented in Figure 5-2.

The rough separation process can be placed either above the sea or at the seabed. A third version is to split the process and have a part of the separation at the seabed and the other part above the sea.

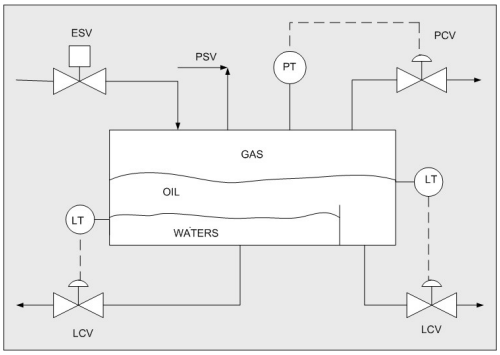


Figure 5-2 a *synoptic sketch on the separation process of gas, oil and water*

The separation processes include important measurement instruments in conformity with many other systems at plants in the oil and gas industry. Traditionally all

readings of the measurement instruments needed to be done manually by an operator directly on the measurement instrument. At platforms today the most values of measurements can only be read in the control room. But there are still a few that need to be read directly on the measurement instrument and some measurement instrument can be read both in control room and direct on the measurement instrument. The vision of the future in StatoilHydro is that any operator independent on their geographical position should have the possibility to read the measurement instruments at any platform and in that way have control on the different processes at the plant they are responsible for.

To have control over all processes at a platform is important. Today computers are more and more used. The process control can be everything from simple manual actions to high technology solutions. The process control systems should be designed in a way that minimizes number of cases that result in an activation of the secondary safety system. [32]

On old platforms all process controls were done by manual actions. Today the evolution goes into automatic control with can perform *"closer control of the process operating conditions and therefore increase efficiencies"* [32]. How far in the evolution to automatic control depends on the country and can differ from platform to platform. Today it is common to have control rooms at the plant with real-time video displays. Workers are still needed even when changing from manual control to automatic control, but they can be moved from the process area to a control room and control the display instead of the physical equipments. But still operators need to go out in the process when something unpredicted appears. Person errors can never be zero so the control systems need to handle them. In the future the control room maybe will be moved from the plant to land-bas offices, this evolution has already started. A process plant is a hazard environment, therefore is it safer to decrease the number of people needed to be at the plants. One vision of the future is processes totally controlled and processed from land without any workers on, Sintef[3] is doing future researches on that [43]. More about Sintef project can be written in Appendix 2.

How intelligent a control system can be depends on the fantasy of its designer and the power of the microprocessor. Microprocessor is a common component in a control system. A control system can include measurements, displays, alarms, control loops, protective systems, interlocks, special valves (e.g. PSV, check valves etc.), failure modes and controller mechanisms (i.e. PLC's). When designing a control system for the oil and gas industry it will be designed in a way that Safety Integrity Level (SIL) can be fulfilled (see standard EN61508).

How good a control system works in the reality does not only depend on the technology, it also depends on the interface between the technology and the workers. Three important questions to ask to get a feeling on if the control system works good in the reality disregard the technology are: Are right information presented? Are the information presented in an understandable way? Do the operators accept the system? It is not enough to indicate that the function i.e. open a valve is activated, the operator

[3] A research institute

also needs to know that the valve really is open. In the same way it is better to alarm before something will occur than at the time it occurs, so that an accident may be avoided. The values need to be indicated in an understandably way to be useful, because *"when information is confusing, lacking or overtaxing, the ability to understand and act upon it quickly or effectively is absent"*. [32]

In the oil and gas industry there are many pipes, valves, compressor etc in use with appurtenant measurement instruments. All these components and instruments in the oil and gas industry need to work together as complete system. The better the systems are more money can be earned and the safety will increase at the platform.

A platform is not just a place for producing oil and gas. Persons are working and living at the platform and that sets high demand on the safety. A lot of help systems are placed at the platform to a sure that the production process works well and to maintain a good working and living environment for the workers at the plant.

To work for a safety environment for all involved is a central job assignment in the oil and gas industry. It is common to do hazard and safety analyses on processes at the platforms and researches on new innovation solutions are always in process. Below are a few innovation solutions directly connected to safety at platforms presented [6].

- Freefall lifeboats
- Fire safety exit from al parts of the platform
- Shutting off valves if an accident should appear
- Physic separation of the living quarter, process system and well head system
- Computer steered control and shutting off of the process

The technology safety system at a platform goes under Safety Instrumented System (SIS). These systems are built up of sensors (e.g. load gauge), equipments (e.g. valve) and logical solving (e.g. programmable logical controlling). Two examples of equipments that belong to SIS are overpressure safeties and shutting off valves. In a SIS system, system failure is not allowed and one way to avert system failure is redundant systems. Redundant systems are necessary to have, but it increases the complexity. One example on a redundant system at the platform is the diesel motor driven generator that starts generating power if the head power generator will stop of any reason. [6]

5.2 The Complexity in Developing of New Products for the Oil and Gas Industry

The oil and gas industry is one of the hardest industries to implement new technology into. The reason for why the oil and gas industry come after other industries in adapting new technology is because of the long time from an innovation to a final product. The safety demands in the oil and gas industry are high. Before a product or a prototype can be used in a plant it must be proved that it will not make any damages. Calculations (SIL), validations and certifications (EX) are needed, which take time.

The oil and gas industry is going into a new phase where the focus is moved from the technology and its safety aspect, to the whole organisation and how it can improve a higher level of safety. In development of new systems for the oil and gas industry the systems need to improve the demand of concepts, as HSE, MTO, sociotechnology and Resilience engineering.

HSE (*"health, safety, security and the environment"*) is a central concept in all parts and activities at StatoilHydro. StatoilHydro follows 6 points according to the concept HSE [46]:

- *"We integrate HSE in all business activities to create safe and healthy workplaces"*
- *"We conduct our business in accordance with our ethical principles"*
- *"We select supplier based on commitment and performance"*
- *"We engage with stakeholders and communicate our ambitions and performance"*
- *"We are committed to reducing the negative impact of our activities and products on health and environment"*
- *"We evaluate and improve our performance continuously"*

MTO (*"Man, technology and the organisation")* is the idea that these three parameters will influence on the safety and risk level. Today MTO is a well known concept at StatoilHydro in all levels of the organisation. At all plants in the oil and gas industry it is important to have a high level of safety and decrease the risk. At Tjeldbergodden MTO is one of the first things you learn about in the safety course, which is necessary to pass to get access to the plant. In the course they talk about MTO as the three safety barriers human, technical and organisation. Visually it can be described as the Figure 5-3.

Figure 5-3 the three safety barriers at a plant related to concept MTO.

5.3 Integrated Operations (IO) at StatoilHydro

The traditional way of working in the oil and gas industry, was that all offshore plants were separated from both land and each other. That means that the plants did not operate together and they did not communicate much in their daily working processes. On a plant workers with different competence are needed, not only the workers who work with support of the daily processes in the plant. In some processes at the plant and when problems occur experts in that specific area are needed. Traditionally experts are at the platforms all the time or travel out when they are needed, which is

time consuming and expensive [54]. Now days the oil and gas industry does researches to develop new methods of working, which will increase the safety and decreases the costs. The name of the research differs from different companies [1]:

StatoilHydro – "*Integrated Operation (IO*)"
Shell - *"Smart Field"*
BP - *"Field in the future"*
Chevron - *"i-filed"*

Statoil's definition of IO is *"collaboration across disciplines, companies and organizational and geographical boundaries, made possible by real-time data and new work processes, in order to reach safer and better decisions - faster"* [1]. The project that works with IO at StatoilHydro goes under the name TAIL IO and is running since 2006. StatoilHydro works together with four partners in the TAIL IO project, they are ABB, IBM, SKF and Aker Solution. The reasons for involving partners in projects at StatoilHydro are that the technology becomes more and more complex and the deposit becomes higher. To get a high result, collaboration with other companies which have good knowledge in areas that StatoilHydro is weak in is needed. StatoilHydro will increase its collaboration with other companies [30]. Working with partners also generates the possibility to have influence on the development in partners companies. Because the oil and gas industry operates in hazardous environments, many products needed to be EX certified. The EX market is traditionally not large in comparison to the non EX market. With collaboration StatoilHydro can influence companies to develop products more according to their needs. The TAIL IO project is divided into seven subprojects [48]:

F0: Common Integration Architecture
F1: Condition and Performance Monitoring
F2: Turnarounds and Shutdowns
F3: Wireless Communication and wireless sensors
F4: Collaborative Visualization
F5: Mobile ICT Infrastructure
F6: Robotics Technology

All F projects are closely linked to each other. F0 will provide a standard software platform or integration layer for all of them.

The aim with TAIL IO is to let offshore workers (at platforms and ships) and onshore workers work closer together sharing real-time data with each other via *"digital services"* [35] for solving problems and follow the processes (eg. drillings) at the plants. One of the strongest changes will be that engineers and experts can support processes at both offshore- and onshore plants far away, from for example land-based offices. Below are four real use cases:

Drilling
Drilling of new wells is a complex and time consuming process, which are done in many steps. The new technology gives operators offshore and engineers onshore the possibility to follow the process and read the values from the same instruments [54].

With real time data from the drilling instruments the operators and engineers can discover errors before they emerge. Here the new technology according to IO may save both time and money, and this has been done already.

Health care
Offshore platforms are located in the sea far from land and when someone gets really ill, e.g. get a heart attack, a doctor is needed. It takes time for the doctor to travel to the platform or for the patient to travel to the hospital. The new technology will give the doctor the possibility to follow the values (e.g. blood pressure) of the patient during the travel time. Benefits can be that the doctor can:

- provide information to the persons who take care of the patient about how to help the patent
- take a decision about how to help the patent before they meet
- prepared necessary things e.g. an operation table

Optimization of the production
The goal is to optimize the production and maximizing the production of the field yield. In the traditional way of working it could take *"weeks or months to gather and synthesize information"* [24]. In use of wireless sensors which send real-time data, the workers can do a better optimization in control of flow from the wells with oil and gas. The sensors may for example generate information about the pressure and the temperature at different places in the fields and the *"movement of gas or oil deposits within the field"*
[24].

Condition and performance monitoring
Condition and performance is a sub-project in the F1 project. This sub-project *"focuses on condition- and performance monitoring of critical sub-sea and topside equipment [48]."* Their idea is to have the possibility of monitoring the status of large equipments as e.g. compressors and turbines. One example can be monitoring the effect which a gas turbine generates, to have the possibility to in an early state detect when the turbine needs maintenance. All tears at devices can not be direct measurement, other measurements and calculations will be needed to have the possibility to say something about the desired status parameter. How to do this is one thing F1 looks at.

IO will generate benefits to the oil and gas industry in many ways not only the most important, which is higher safety. StatoilHydro calculates to decrease their cost with 5% by introducing IO. Below follows a list over examples on benefits from introducing IO [20]:

- *"Improved HSE (health, safety and environment)"*
- *"More efficient drilling operations"*
- *"Better placement of wells"*
- *"Production optimisations"*
- *"Increase recovery"*
- *"Better reservoir and production control"*
- *"Better monitoring of equipment and more efficient maintenance"*

- *"Better resource exploitation"*
- *"Increased regularity (uptime)"*

Introduction of IO in the oil and gas industry will move workers onshore from offshore and generate a new organisation structure [20]. New integrated operation facilities/infrastructures need to be built both onshore and offshore, where the workers will work [35] together to achieve the new organisation structure adapted to IO. The new organisation structure will affect the workers situation more or less. Below follow examples on the changes a worker may meet [36]:

- New job assignments
- Geographic move of their work, which can generate a new economical situation
- New status of job position
- The social situation at work can be changed

These changes can generate opposition among the workers. To avoid opposition it is important to inform and explain why the changes are needed for all involved persons in an early phase of the change process. Another important social factor to work on for doing the changes easy is confidence. Confidence in implementation of IO solutions can be seen in different ways, the four main ways are [36]:

- Confidence between onshore and offshore workers, who will do what and they need to have understanding of each other
- Confidence in the working team, who have which competence and who will do what
- Confidence of the new technology
- Confidence to their own competence and their own knowledge about the new technology which will be used

5.4 Wireless Technology in the Oil and Gas Industry

The use of wireless technology has increased and will probability increase more in the future. As Paula Doyle said during the wireless seminar (chapter 4.3.2), wireless is the future of intelligent environment. The oil and gas industry is interested of wireless technology because it can reduce the operating costs, decrease the installation costs and increase the safety [15].

At StatoilHydro two types of wireless technology are in focus today, WLAN (Wireless Local Area Networks) and WSN (Wireless Sensor Network). StatoilHydro is also interested of other types of wireless technology, which can meet their needs.

WLAN is made for wireless internet connections. Today StatoilHydro has a WLAN solution from Telenor at their land-based offices, but the desktop PC normally uses cable connection. There are no wireless solutions in the process plants today, but will probably be it in a near future. The distances at onshore plants are substantial and that have generated an interest of the new wireless internet technology WiMAX at StatoilHydro. WSN are used in researches today at StatoilHydro, to evaluate the

possibly to have systems with wireless sensors in the processes. During the spring 2008 StatoilHydro is doing research on the standard WirelessHART.

5.5 Tjeldbergodden, the Reference Plant for the Research

Tjeldbergodden is an onshore methanol production plant, which is placed west of Trondheim and is certified in accordance with ISO 9001 and ISO 14001. The processes at Tjeldbergodden was started-up 1997 and StatoilHydro is the principal owner and the one who operates the plant. Other companies which are part owners in different parts of the plant are Conoco Phillips, ENI Norge, Petoro and AGA [47]. Tjeldbergodden has one ASU-plant (Air Separation Unit), one LNG-plant (Liquid Natural Gas), one Metanol-plant (SMA) and one GRF (Gas Receiving plant) which receives gas from Heidrun by the duct Haltenpipe, which is 250km long [31].

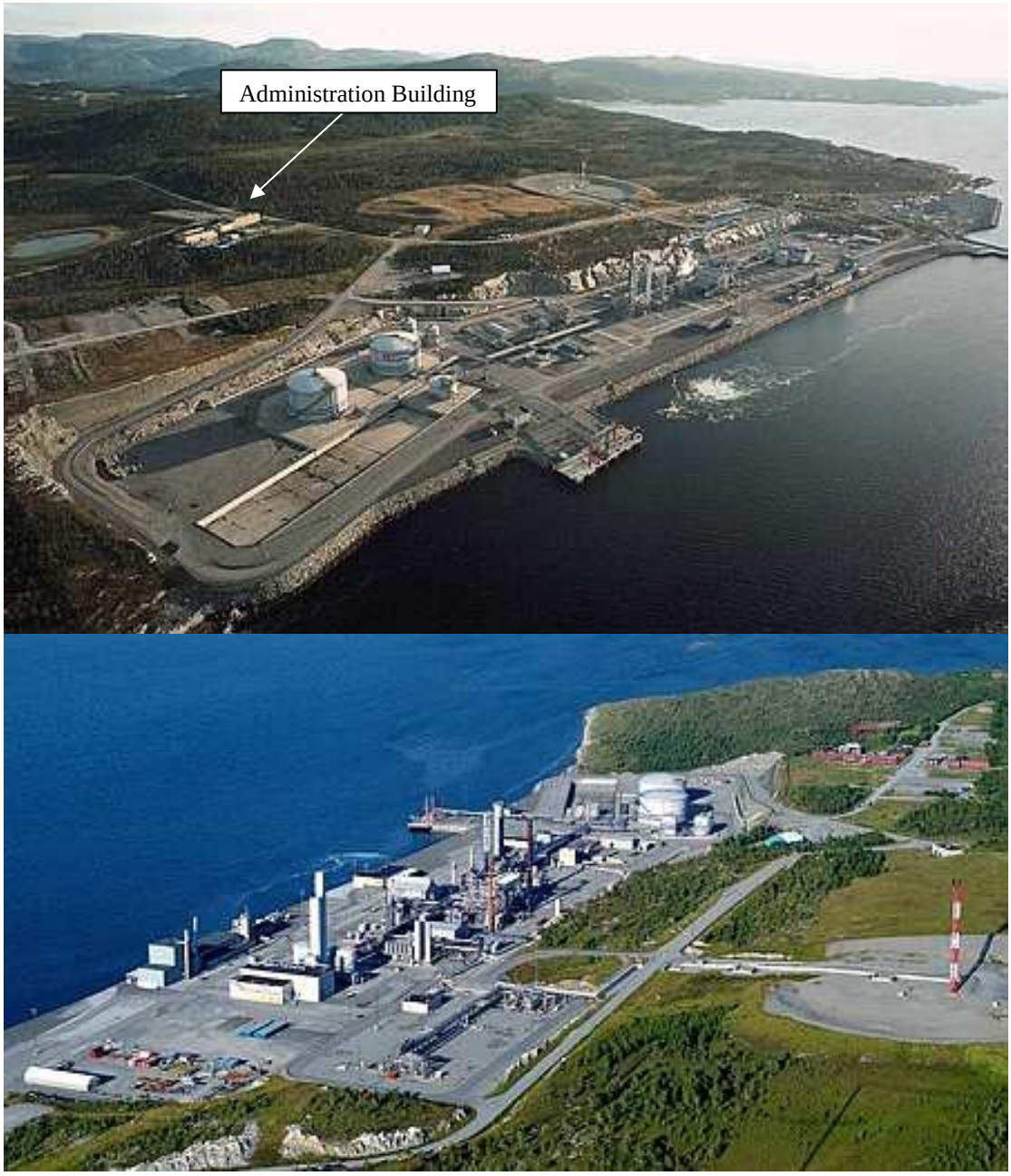


Figure 5-4 ***Flight photos of Tjeldbergodden (Copyright StatoilHydro)***

The organisation at Tjeldbergodden is rather unique. Tjeldbergodden has a flat organisation, where all employees are located in the administration building outside the process area of the plant and they work close together. The workers travel between the administration building and the process area of the plant by cars and the distance is around 800 meters and pretty steep, can be seen in Figure 5-4. The shift teams at Tjeldbergodden are responsible for the daily control of the plant and the shift teams are organised in a unique way. Every team are organised in a:

- multi skilled way. Persons with skills (certification apprentice) in all different fields, electrical, automation, mechanical, process and laboratory work [47]. This generates the advantage that the shift can do repairs and maintenances by them self, when minor errors appear
- multi responsibly way. The processes in the plant are divided into different parts, to learn one part can take between two weeks and a half year. Most operators at Tjeldbergodden have knowledge in more than one part. Each team needs to have knowledge in all parts
- multi emergency way. All teams at Tjeldbergodden are also an emergency team, which include smoke drivers, a fire engine and an emergency contingency vehicle. At plants it is a demand to have an emergency team, to have it in the shift generate fewer employees.

The technology solution at Tjeldbergodden is more automated in relation to other plants. Most of the devices (all critical) are controlled by a PLC system from ABB. All critical instruments send real-time information by wire into the control room. Between the PLC system and the control room monitorss is a software network implemented, which the control room operators interact with. As a safety solution are PLC control panels for the PLC systems also located in the control room, if the software network break down the control room operators can interact direct with the PLC system through the PLC control panels. There are still measurement instruments that need manual reading. The operators are controlling these measurement instruments (their normal values are known of the operators) and looking after abnormal heats, smells, gases etc during their daily turns in the processes at the plant, which are done 2-3 times every shift (6-9/day). The values of the manually read instruments at Tjeldbergodden are not logged. On other plants with fewer automatics, the operators need to do manually reading of instruments, which values need to be documented.

Today there are no wireless solutions out in the plant at Tjeldbergodden. A project group with members from three onshore plants are discussing the opportunity of install wireless at their plants and they are looking for using areas of wireless which can generate high profit. They have decided to start testing wireless solutions in plants when where are use areas that will generate high profit. In the administration building at Tjeldbergodden a wireless network was implemented 2006.

As at all plants in the oil and gas industry the safety demands are high, this to minimise the risks for accidents and limit the damages if an accident should appear. Daily works are running at Tjeldbergodden to continuous increase the safety and decrease the risks. As at all other plants in the oil and gas industry the plant at Tjeldbergodden is an EX zone and no other technologies than the EX certified technologies are allowed to be brought into the plant from the administration building. The only technologies the operators in the processes at Tjeldbergodden in conforming to other plants have assistance from are radio which is EX classified, pencil, pocket-book (to write in), W.P. (in paper format), drawings (in paper format) and the tools in their tool belts.

6 FINDINGS AND IDEAS

This chapter is divided into three sub sections. The first section (6.1) presents a conclusion of my findings and ideas from my first visit at Tjeldbergodden and the first two rounds of interviews. Those findings and ideas were evaluated during my second visit at Tjeldbergodden. The second section (6.2) of this chapter presents the results from the evaluation of some of the first section's findings and ideas, and new ideas and findings from the second visit at Tjeldbergodden. The third section (6.3) presents the findings from the third visit at Tjeldbergodden, when the idea with the mobile office became verified.

6.1 Findings with result in the question: can the cars be used to do the plant more intelligent

Before I did this research, I always thought about oil and gas plants as offshore rigs. But during the research I have found that there are many types of plants. I have divided them into four types of plants, offshore plant (a production plant of oil and gas in the sea), onshore plant (a production plant of oil and gas on main land), refinery and other onshore plant (production of NLG, methanol etc on main land) (Figure 6-1).

Figure 6-1 I have divided the plants in the oil and gas industry into four types of plants, offshore plant (a production plant of oil and gas in the sea), onshore plant (a production plant of oil and gas on main land), refinery and other onshore plant (production of NLG, methanol etc on main land)

My conclusion is that it is hard to find two plants which have of the same design. I have only found two which are a copy of each other (Gullflaks A and C). The technology- and the safety evolutions have increased fast after the Second World War and that have affected the design of the plants. My findings are that for every new plant that is build, there are new safety demands to consider, new technologies which can be used and new trends of organization to adapt, and all these will affect the design of the plant.

One of interviewee had earlier worked at Gullflaks and later participated in the design of Snøvit. The interviewee has experienced that the demands on safety equipments have increase since the interviewee's time at Gullflaks.

One person at Tjeldbergodden talked about how the ideas of a flat organization have influenced the design of Tjeldbergodden.

The reason for why the plants are not rebuilt after the latest trends, I think is because it is difficult to rebuild plants. But some modifications are done and are necessary to do for reach new safety demands etc.

During one of the interviewee's time at the Gullflaks, great changes were done. The production did not work well after that. The interviewee's work was to systematic go through the parts of the process that not worked sufficient and to find the reason for the problems. The reasons for the problems were devices that were not cleaned, devices that were rigged up wrong and temperature or pressure settings that were wrong etc.

The plants include many systems and systems today become more and more complex. I have illustrated that as a seesaw with complexity on one side and technologies on the other side (Figure 6-2). Another way I had illustrated a plant is as the earth. In that meaning, I believe that all technologies which can be found around the world can be used in a plant. There is just one problem, devices at a plant need to be EX and SIL certified etc, of the reason that mediums at plants are related with high explosion risks. At the market today there are a lot of good technology solutions that should fit great into the oil and gas industry if they have been EX, SIL certified etc.

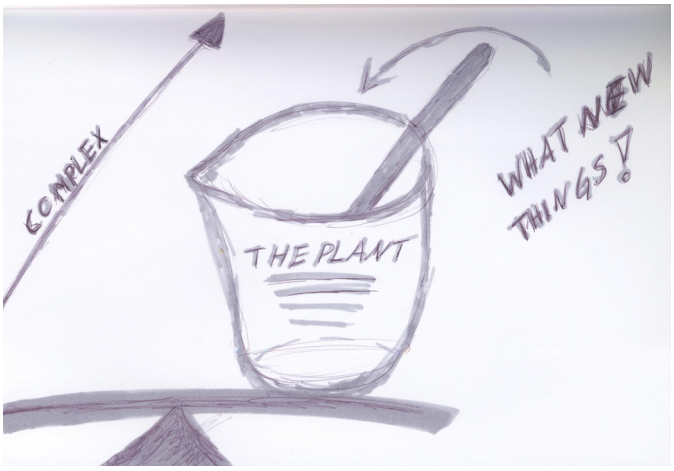


Figure 6-2 my illustration of the balance between complexity and technologies at a plant

It is always a goal to place different parts of the process, which are associated with high risks, far from each other and to have as little personnel as possible in those processes. But on the other hand it generates long distances and that is seen as a problem according to some persons (not of all I have interviewed). At onshore plants vehicles (cars, bikes, etc) are used to reach different places in the process faster. No one wants to spend time in walking a few kilometres for a work, especially not in emergency situations. The knowledge that they use cars at onshore plants gave me the idea:

Why not use the vehicles at the plants in a more intelligent way (not just for transport)?

Today computers are implemented in cars. Car companies are doing research on how to communicate from computers indoors with the computers in the cars. VISAS (a research centre in Gothenburg) are studying how the computers in the cars could communicate with the surrounding around the car. I think this idea can be used in the oil and gas industry to do the plants more intelligent.

One other thought I have, is about cameras.
Surveillance- and a few IR cameras are used in traditional ways at some plants. Can the cameras picture be used for automatically registration of a change in the environment (example with AI algorithms)?

6.2 Findings about what the cars can be used for

During my second visit (three days) at Tjeldbergodden, I did both interviews and participant observations. During this visit I got new ideas, new knowledge and collected ideas from the workers. All those findings and ideas are presented in this part of the paper. It is hard to separate from who the different ideas come from. A few have I got direct from other persons, most of the ideas have I either found out self or from problem I have heard about or seen during the studies. If all ideas could generate a more intelligent environment can be discussed, it depends on our view of the concept intelligent environment. If we look at an intelligent environment as one which includes equipments that can think by themselves, all ideas will not fit in. If we look at an intelligent environment as an environment that is built up to make it easier for the workers to do their work, most of the ideas will fit in.

The idea with using the cars for more than transport generated positive response from several workers at Tjeldbergodden. The dream scenario for the most of the operators at Tjeldbergodden was a PDA with a tag reader to bring with them into the processes (EX zones) at the plant. There are projects running on PDA at StatoilHydro, and I think PDA will be used in process plants in the oil and gas industry in the future. To have the cars as mobile offices for the operators out in the plant generated good responses. Today they need to go to the administration building to use the computers for example print out papers or to the jet office (not a common alternative among the workers). I learned during my second visit that the cars had more functions than transport. The smoke-driver leader always wants to have the smoke-driver equipments nearby, which are stored in the car. The cars are only allowed to be drive at the roads in the plant area, and for entering the plant area with extern cars permissions are needed.

At Tjeldbergodden they use 4WD diesel cars (Mitsubishi L200, Toyota HI-LUX, Toyota HiACE). They had smaller cars before, but they broke done too easily. They need strong cars which they can load with devices and to drive out to the process area of the plnat and do work. The climate here in the north is also a reason to the choice of cars. Between the administration building and the process area at Tjeldbergodden there is a sharp hillside and in the winter 4WD is a good to pass that hillside. The

reason to have diesel cars, are that a diesel tank can be placed above the ground and there is a diesel station that offer diesel close to Tjeldbergodden. The closest gas station is located over 20 km from Tjeldbergodden.

Now back to the idea of using the cars as mobile offices. This idea should generate less travel to the administration building to only print papers, easier to premeditation works, effective the learning process of apprentice etc. A lot of suggestions of what could be implemented into the car came during my visit at Tjeldbergodden. These suggestions are presented done in the point-lists below:

Solutions on how to make the work at plants more mobile

- Computer with access to the normal user login at StatoilHydro. One good thing with a normal PC is that it is a well known technology (some persons are always sceptic to new technologies)
- Access to document as, P&ID, W.P, access paper for extern cars which will enter the plant
- Printer, to print out needed documents, drawings etc
- Access to the process overviews which are shown in the control room (read only is enough). The operators think they miss the total view of the plant when they leave the control room
- Battery chargers for the radio, which are only located in the control room and jet office today at Tjeldbergodden
- I asked one apprentice how many monitors the apprentice thought the car could need and the answer was that probably one would be enough
- Normally there is one operator (form the shift team) in every car
- Equipments which can help the workers open/close tubes, for example an air-power engine (an idea from an operator). Many tubes need muscle-power to be opened or closed and it can take over 20 minutes to open/close one large tube. This equipment can be placed in the cars for always be available for the operators

Solutions on how to make the mobile work more intelligent

- Surveillance cameras which could send real-time pictures to the control room. Maybe surveillance camera on the roof of the car, placed on an arm that can be rise up and controlled in all directions. Generates the possibility to take pictures of places where the fixed surveillance cameras do not reach or at places where fixed cameras not are needed
- A mobile camera on the helmet (to have the possible to work or climb and take pictures at the same time) to bring out in the plant and do real-time pictures, which can be shared with the control room. This will generate easier problem solving between the control room and the operators out in the process area of the plant
- The idea of having a GPS system to easier find devices is not very much needed according many workers, at the plants. Many said that for new persons it maybe good. My experience during my research is that the idea with a GPS has generated different opinions, the most of workers that daily work in the plants do not think it is necessary

Solution on how to make the mobile and intelligent work more safety

- Skype and/or msn, possibility to have direct and "private" communication. On the radio it is always some noise. In conversations when it is important that the right information reach the receiver, radio is not a optimal tool. In the process with ships, phones are used in the conversation between the control room and the jet office in delivery of important measurement values. The will of using written communication as msn, depend on the person's age and interest of adapting new technologies. As a joke one operator said that Facebook will be good to have in the cars
- Mobile gas detectors. My idea was also to have a gas detector at the roof of the car. Later I got the information that it needs to be gigantic gas leakage for the gas to reach the roads. Today gas detectors need to be reached by the gas before an alarm generates, new types are coming in a close future
- To have a map that shows the shortest and most safe way to drive is a good idea. When a gas leak has appeared it is good if the driver will be recommended a way to drive with out passing the gas leak. To pass a gas leak in a plant is no healthy and is combined with risks. A map that recommends the shortest and most safe way (in real-time) can be designed and evaluated in for example **Matlab with a TSP algorithm**. The algorithm may also take into consideration the wind direction
- An intelligent robot that can leave the car and make the daily round in the process area of the plant and then go back to the car (will discuss the robot later in this section). If the robots walk by themselves, it will result in less person in the process (the process area is not a safe environment to be in) (a deeper discussion about the robot is presented later in this part of the thesis)
- Connect the real position of the car at the road in the plant with Knut-Olav Fjells 3D world of the plant. In that way you can travel around with the car at the roads (which not are EX zones) in the plant and show visitors, teach apprentices etc about the processes at the plant, when they both see the real plant and the 3D view. When stopping the car you can walk in the 3D world instead of entering the hazard environment in reality and then head back to the car
- The blue and yellow signal flashes lights (alarm signals) in the plant are difficult to see in strong sunshine. I got the idea of having a high pole with a "light" that light up the whole warning area in blue respective yellow. Then the worker I talk with generated the idea of why not light up the whole pole. In one of the courses I had last autumn we had an exercise in finding use areas for a power cable which visually shows the amount power that are transported through it. Lights flow as a spiral around the cable with different rate and light intensity depending on the current level through it. Maybe this can be used in some way. When have a high pole with generate colour in someway it will be easy to see from the cars by the operator or the car can collect that information by itself if the car will act as an intelligent agent

I also tried to find information that the car could receive during its "travel", but I could not find any direct relevant information in to days design of plants. My solution is that the roads are beside the process area of the plant today and that demand the use

of the car as an “intelligent collector”. When building a new plant the roads and process areas could be designed in a more integrated way, to generate the possibility of collecting data from the processes in the plant with the car and that will make the cars as an **intelligent agent**.

Before ending this sub-chapter I will shortly present a deeper discussion about intelligent robot and the status on wireless network on onshore plants in Norway.

An intelligent robot
Today the operators use the human’s senses, smell, hearing, feeling and possibly to remember when they walk their daily rounds in the process at Tjeldbergodden. They put their hands on pipes for feeling temperatures and vibrations, smell in the air for gas leak and listen for abnormal sounds in the process. There are still measurement instruments in the plant that need to be read manually. The operators know that these measurement instruments will bee in normal mode for his/her responsible area of the plant (many operators can more than one part and I was told that it take between two weeks and half a year to learn one part of the plant). If the daily round should be done by a robot instead of a human, I think the robot will need some “human quality”. First the robot must be built in a way that it can pass over a ground with macadam, step over pipes, walk stairs, climb ladders etc. The robot needs to have a “hand” with temperature- and vibration sensors to feel temperatures and vibrations in tubs. My notion was that the measurement instruments that needed to be read manually commonly were placed in groups. To read those measurement instruments (all in one group together) the robot can have a camera eye that takes pictures of the groups of measurement instruments and later analyse them. I think that all measurement instruments in the same group have connections to each other, other way it should be a bad idea to analyse them together. The robot can also bring a gas detector to have the possibly to do gas measurements. I do not think that the robot will need to send all the information to an operator placed somewhere, to control it. **The robot can have knowledge and AI algorithms can be used to learn the robot the accepted temperatures, vibrations and what the pictures of the measurement instruments will look like**. When and how the robot can send information about errors depend on what the wireless network will look like. One thing not to forget, the robot needs to have the possibility to clear cans from water, waste oil etc. Today intelligent research robots have been constructed at different research centres around the world. I do not think it is an easy to build an intelligent robot for the oil and gas industry today. Because most of intelligent robots which use learning algorithms are in a research state and to get the robots EX certificated, may be can be hard.

Wireless at plants
Today there is no wireless network solution in the process area at Tjeldbergodden. The administration building has a wireless network since 2006. Today there is a project between Tjeldbergodden, Kalundborg and Mongstad, which look into the possibility of extending the office network out into the process area of the plants. But the project will not do any tests with wireless network before there are good reasons to why a wireless network should be implemented. The use of USB wireless network is not possible of safety reasons. If a wireless network should cover the whole process area or only part of it could be discussed. If just parts of the process area, it can

demand the workers to only use the wireless network in safe places. One thought is to have mobile network access point at roof of the cars. In the future the plants will probably have wireless networks and that will increase the opportunities to make more intelligent environments.

It is a hard decision to make, between how much information that should be moved out into the process part of the plant according to the goal of not having persons in hazard environments, as the process area at the plants are.

Finally I think Tjeldbergodden has great and usefully technologies in all their meeting rooms. People were friendly and helpful during my visit and in the control room all operators were proud over their new great monitors.

One of the interviewee said:
"It is only the fantasy of the humans that limit what can be done, the technologies are there"

6.3 The result from the verifying of the mobile office's design

During my third visit at Tjeldbergodden I evaluated the concept of a mobile office with operators from two different shifts and operators in the workshop. To my help I had the pictures in Figure 4-4. I also had a talk with 3 external operators about their work. A conclusion of the findings I got will be presented here.

Most of the operators were positive to the concept of a mobile office, and saw it as a time saving idea (which is one of the goals with the concept).

The mobile office location in the cars
Most of the operators want to have the computer located so that it could be used from the driver's stand. The operators want to have the possibility to sit in the car and use the computer in bad weather as rain, snow and hard wind, which is common in the north. Most of the operators were realistic and think the other part of the mobile office should be in the back of the car, because of the limit space in the front. The operators in the workshop used to drive together in teams of two or three persons and fills up the front seats of the cars. Several of the operators commented that it would be great if every equipment (as printer, camera etc) had its own place in the box.

The comments about the demand on the computer
A general comment from the operators was, not to small computer monitor a larger will be better. Around 15 inches was the most common answer, but many also said larger than 12 inches. Some of the operators said as large monitors as possible in relation to the space in the car. Comments about why a large monitor was needed were, it is hard to see drawings on small monitors and older persons have weaker eyesight. Some said the computer needs to be robust. Operators sometime have dirty fingers and maybe will use their gloves even in the car. One operator commented that the computer monitor needs to have the possibility to offer good picture even in strong sun shine.

The comments about the demand on the printer
When I asked which size of paper the printer should generate, (A4 or A3), most of the operators said A3, because the P&ID drawings are hard to read on A4. Some said both A4 and A3. I think it will be most useful to have the possibility too print both on A4 and on A3, because W.P. is print at A4 and P&ID is print at A3 and these two will presumably be the most printed documents in a mobile office. To print W.P. and P&ID documents only black and white printers are needed. One operator thinks that laser printer stand damp better.

The comments about the gas detectors in the mobile office
Idea of having gas detectors located in the car generated the comment, it is important to have them in the cars. I was told that the small gas detectors used for human safety will be good to have fixed installed with its loader in the cars. The large detector use to do measurements with, need to be calibrated every night in the administration building. A place to put the larger gas detector in the mobile office will be great.

The comments about to have an EX camera in the mobile office
All the operators in the workshop I talked with think it is a great idea of having an EX camera in the cars. They will really have use of it. Most of the operator in the shifts saw no use of an EX camera in the cars. A few of the operator in the shift said it could be great in revisions dance. The operators in the shifts do not take many pictures today. The question about an EX camera in the mobile office generated discussions about today rules of photographing in the plant. I asked one of the shift leaders about the rules for photographing and got a document with rules about different works in the process area of the plant. In that document it can be read that a StatoilHydro employee can take picture with an EX camera with only oral acceptance from the shift leader. For an extern person it is harder, more acceptances are needed. Another comment was, it must be easy to move pictures from the camera to the computer.

The comments about use MSN as communication medium from the process area of the plant
Today all employees at StatoilHydro around the whole world have the possibility to use msn. At Tjeldbergodden (as at other plants) radio is used to communication among the operators. I asked if they could make use of msn in mobile office to get the possibility to communicate with person not using radio for example the engineers.

I got a feeling of that the use of msn differs a lot. Younger persons and persons that like to adapt new technologies use msn and others do not use it commonly. I think msn was a hard thing to ask about, many of the operators saw the benefits from it when I presented them and they also think the different functions on msn could be useful. As one said, I do not see any use of it today, but I will presumably do it the day I have it in the car. The possibility to send documents, links, pictures many liked. I think good reasons to use it need to be evaluated and the reasons need be presented in a good way to do reality of the use of msn in a mobile office.

The possibility to do own status icons in msn
This idea generated good response from some and really negative critic from some. Some persons find it really insulting on one's integrity. I learned to present the idea in

a more neutral way. I started with saying that the purpose with own status icons is not surveiling of persons, it is more for safety. If an accident in one part of the process area of the plant appears, it will be good to know who are in there. Some persons said it will be a great function if every one uses it, today it is hard to get people to write "out of office "in outlook. One person commented that it should be great to make the position of the operators in the emergency team visible in msn.

The insulting on person's integrity is frequently discussed in many areas today. For example surveillance cameras as public places, the local traffic card in Gothenburg which save person's travel history for a while. I believe that people's acceptance on integrity will increase in the future. Ideas that influence on people's integrity need to be presented in away so the good and strong reasons are understood and accepted of people.

Other technical components that will be great to have in the mobile office
In the discussion about if msn could be useful, the operator in the workshop commented that a telephone should be great. The operators in the workshop said it should be great to have the possibility to phone the supplier from the plant when errors on equipments are discovered. Their idea was a fixed phone in the cars or an EX mobile phone. I later get the idea of having an IP telephone on the computer. The operator also said it should have been great to have the possibility to send pictures to the supplier.

Today the radios are connected to the operators' headset, which is built-in in their hear protection. It should have been great if the same headset could be used when communicating over other communication mediums in the car.

Web cameras if it should be possible to use the video conference function on msn.

One operator said a GPS on the car, to find new person in the plant who not knows where they are.

Today when an accident appear and the control room needs to come in contact with all operators in the process area of the plant, the control room sends a message over radio and all operators in the process area of the plant need to answer the message over radio. When it is many operators in the process area of the plant who will make an answer by radio at the some time, it can be collisions in the radio communication. An answer button in the cars which send its status to the control room can decrease the communication over radio. If all operators in the cars press the button instead of answer the message, which all need to answer, over radio, the risk for collision over radio will decrease.

Comments about the power supply to the mobile office
A mobile office needs power as all other offices. Today computers and printers can run on batteries, but the disadvantage with use of batteries is that the batteries need to bee loaded. The mobile office will need some type of power solution, and the question is how much work with power solution the operators willing to do, to have use of a mobile office. When I asked at Siba about the normal battery time of a laptop, I got

the answer 2 hour (more when the batteries are new). On internet I have found batteries with a battery time up to 9.5 hour. I do not think the use of batteries is a good solution, because it generates two actions from the operators. The first action is taking in the batteries for loading and then brings new batteries out the next time the operators travel to the process area of the plant which can be later. The second action is to turn of and on the computer. I asked a few of the operators if they should think it is to much work to plug in a cable when having the car at the parking space, close to the administration building. (Loading stations of power are used to offer power to the ambulances in Sweden.) Most of the asked operators said no, it only needs to be a routine on plug in a cable into the cars at the parking space. Some persons think it generates too much work to plug in a cable at the parking space. One person offer the idea of having the same power solution as the bumper cars at Tivoli and one other said why not have the same power solution as the fire truck at Tjeldbergodden has? The fire truck has a mechanical solution so it can be droved away without manually unplugging the power cable, the contact will automatic be unplugged. On other person told me that this function with automatic unplugging of the power cable was only used in emergency situations, because it tears on the contact. In not emergency situation the power cable is manually unplugged from the fire trucks. One other person commented, the cars are not at the parking space so much during a day (a day = 24 hours).

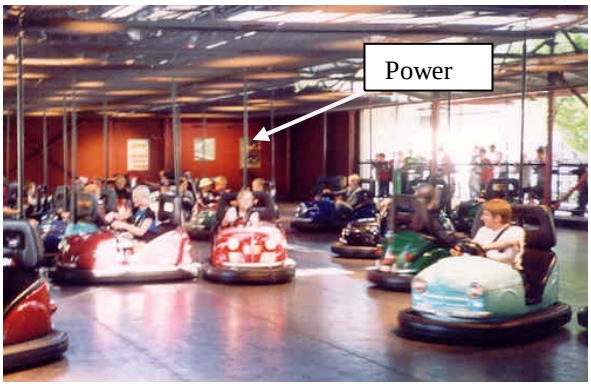


Figure 6-3 the bump cars from a Tivoli. One person at Tjeldbergodden idea was to use the power solution a bump car has to generate for loading power to the mobile office at the parking space [55]

Comments about access to StatoilHydro's data system

The process of getting access to StatoilHydros's data system can take time. Of that reason I was told that it is hard to have mobile offices for borrowing to extern operators, who only should be at the plant a few days. There are external operators located at Tjeldbergodden who do supports in the process. I talked with one team of three external operators and one of them said that he has access to StatoilHydros's data system. Two of them said that they do not know so much about computers and that the shift leaders use to print out the papers they needed. But the one who has access said that he used his login when writing all W.P. for the group.

One operator in one of the shifts told me that the operators do not have access to the drawings that are shown in the control room from their own login. The engineers have access to the drawings from their login.

7 CONCEPT DESCRIPTION OF A MOBILE OFFICE

In the design of this concept, a mobile office to be used in the cars at onshore plants, the knowledge which have been generated during the field studies and the knowledge presented in chapter 2 THEORY have been used.

The operators at plants are mobile workers, they are doing work at different places, in the office building and in the process area of the plant. The operators' mobility can be seen as an expanded version of wandering or local mobility, which were discussed in chapter 2.2. Today the operators are using cars for transport around at the plant. The operators have their office close to the control room in the office building. In the office the operators have their computer to do all their computer works on. The operators are frequently travelling to the process area of the plant for doing work. The operators do not have assistance from any specific intelligent equipment in their work out in the process area of the plant. If the operators need documents, drawings or technical equipments for doing their work in the process area of the plant they need to bring it from the control room or their office. If the operators forgot a needed document, drawing etc or an unexpected job assignment appear during the operators' time in the process area of the plant which required the need of a specific document, drawing or technical equipment, the operators need to travel to the office building to pick it up. The operators have no possibility to do any computer work as mobile work today. The concept will give the operators the possibility to be more flexible, do computer works as mobile work, and decrease their travels to the administration building. The solution is to place a mobile office into the used cars at the onshore plants. This solution can be seen as a ubiquitous computing solution, because it will move the technology to the humans instead of move the humans to the technology, which is done today (the operators today need to travel to the office). In chapter 2.2 was "work changing place" discussed. *"Mobile work does not just "take place" but rather "make places", transforming location as diverse as public and private…"*[13]. When reconstructing a car to a mobile office, I will say that it "make place" for mobile office.

The mobile office built for an already built plant, will only act as a mobile office and a wireless hub. At the onshore plants today it is impossible to do any control of the processes at the plant from the roads. If cars will be used at plants that will be build in the future, the design of the process area of the plant can maybe be build in a way so that the car and its mobile office can be used for doing controls, interact with device beside the road. In that way the car and it mobile office can act like an intelligent agent in the future. On example on how a car can be an intelligent agent will be discussed in the end of this chapter.

This chapter will present the design of the mobile office, suggestions on power solutions, suggestions on wireless network solutions, the benefits a mobile office will generate and a discussion about which safety barriers that will be needed to not decrease the safety.

7.1 The Design of the Mobile Office

The design of the mobile office will continue of two contractions, an arm in the front of the car to place the laptop on and a box in the back of the car with several lockers for the rest equipments in the mobile office. The two constructions will have connection through a cable of the reason that the laptop will get power from the box. The two contractions should be possible to move between cars and the equipments in the mobile office should be possible to change one by one. This design generates the possibility to change the cars without needs a new mobile office and the possibility to change only that equipment which has break down or will be changed of other reasons. The design does not generate the most perfect job possibility, when looking at it in an ergonomic perspective. According to Brown, B and O'Hara, K research [13] workers chose to do different kind of work in different places and the idea behind a mobile office in the cars is to generate the possibility for the operators to do small computer work in the car instead of travel back to the office building. Larger computer works which take long time, the operators will still have the possibility to do in their office, in the office building.

The laptop will be placed in a dock on a mechanical arm in the front seat. The arm will have a hook solution so it can be installed in different types of cars. Figure 7-1 shows pictures on the space in the front seat of a few of the cars at Tjeldbergodden The arm will have a pin-jointed solution so the arm can be moved of the operators into different positions depending on the operators need. When using the computer the computer on its arm should be possible to move into the front of the operator to generate a good working position. When the operator does not want to use the computer more, it should be possibly to move the computer "away". The best solution will be if the arm is designed in a way so it can be used together with different kind of computer in the sizes, 12-15 inches. That will give each plant the possibility to self decide which type of computer to use and the possibility to have the same arm even when switching to a later version of computers. The computer market change much faster than the oil and gas market. It needs to be possible to lock the computer in the arm with a laptop locker[4]. The laptop locker, which will lock the laptop into the arm, will work as a safety barrier. With a laptop locker a physical breach needs to be done to break the barrier to have the possibility to bring the computer into the process area of the plant, with is an EX-zone. It should not be possible for the operator to do a mistake which generates that the laptops leave the cars and enter an EX-zone. The barrier that constrain the operators to lock up the locker and bring the laptop in to the EX-zones at the plant will be the operators knowledge about EX zones and the knowledge about the risks which none EX-equipments in an EX zone can result in. In this design of a mobile office are the computers not EX certified and that limit the use of the computers to inside the cars, but generated a larger selection of laptop to choose among. At the computer market today there are only a few EX certified laptops. But of the reason that the idea is to design the arm in a way so different kind of laptops can be used, it also generate the possibility to use an EX certified laptop.

[4] A chain designed for lock laptops into things during the use of the laptop.

Figure 7-1 shows the space in the front seat of some of the cars at Tjeldbergodden, where the arm with the computer may be placed.

The computers will be used in cars of operators and which generate specific demands on the computers. The operators used gloves in the plant and it is an advantage if they can have their gloves on even when using the mobile office. A plant may be a dirty environment, so the computers need to be robust because the operators' fingers may be are dirty. The computers need to work well in all temperatures as, in hot summer day when the temperature inside the car is high and in a cold winter day. Exactly to which temperatures the computers need to work well in depend on the location of the plant in the world. In cars the space is limit and it generated limitations on the monitor size of the computer. The envisagement angles of the computer monitor needs to be good and the computer monitor needs to have the possibility to generate a good picture even in strong sun shine. To decrease the operators work with the power solution to the mobile office, computers with low energy consumption is needed. In data sheet of laptops they sometimes talk about energy consumption in used mode and sleep mode. Low energy consumption in sleep mode is important to have because the computers will presumably be on the whole day (24 hour), but not used all the time. To the computers it will be great to have a mouse which can be used to control the computer from the operator's hand.

The computer in the cars will include the same programmes, access etc as the operator's computer in the office. To do the mobile office more useful for the operators, the operators should be given access to the same drawings which are shown on the monitors in the control room. An IP-phone on the computers should be great so the operators in the process area of the plant can make calls to persons outside StatoilHydro, direct when the needs appear. It will facilitate the work for the operators

if they can make calls to suppliers when an error on a device discovered direct, instead of travel back to the office building to make the call. All employees in StatoilHydro have today an msn access. The operators work in close collaboration with the engineers and with the msn in the cars the operators can contact the engineers by them selves. Today when an operator out in the process area at Tjeldbergodden needs to come in contact with an engineer at Tjeldbergodden, the operator needs to call the control room over radio and ask them go and find the engineer. (The engineers do not use Radio). Msn has today functions which generate the possibility to send instance message, voice message, doing video conference, application sharing, whiteboard and Microsoft live meeting. The norms for how these msn functions will be use will the operators probably make themselves, according to the discussion in chapter 2.2 *"Many studies have shown that users delevop norms for how, when and for what purpose to use new information and communication technology [50]"*. To have the possibility to use all msn's functions in the mobile office equipments as video camera, microphone and loudspeaker are needed. In the future msn possibly has more functions that can be of interest to use in a mobile office for example have the possibility to making own status icons and have the possibility to shown the operators' positions in the emergency team. Other communication systems than radio which are used at Tjeldbergodden today are a PA system (which generate the possibility to communicate out into the large loudspeakers in the plant from the control room) and VHF system (which generate the possibility to communicate with ships). A function that makes it possible to communicate from the computer to the PA system and to the VHF system will increase the benefit of the mobile offices.

There is a demand for using helmet and hear protection out in the process area of the plant. The radio is usually connected to a headset inside the hear protection device. The mobile office needs a solution so the headset even can be used when communicating over msn and IP-phone. The possibility to use the same headset will make it easier for the operators to shift between the different communications mediums (radio, msn and IP-phone). The new types of communication medium will work as a complement to Radio and increase the possibility to communicate from the process area of the plant.

The other part of the mobile office contraction will be the box which will have several storage lockers with wickets for, a printer, gas detectors and place for their loader, an EX camera and its loader, loader for the radio battery, a place to have papers and pencils in and a power plug-in, so all cables in the mobile office can be collected at the same place in the box. The advantages with a good designed box instead of all equipment as loose piece are, easy to have an arrangement of the equipments and less tear on the equipments. The size of the box is depending on the size of the printer, the size of the other equipments and the space inside the cars. The printer will be placed in the bottom of the box and the rest equipment will have their places above the place for the printer. It should be easy to reach out printed papers and fill the printer with paper through a wicket. The box will have a size so it can be placed behind the driver in the cars. Figure 7-2 shows pictures on the space behind the driver in a few of the cars at Tjeldbergodden.

Figure 7-2 shows the space behind the driver in some of the cars at Tjeldbergodden, where the box with the printer etc may be placed.

The printer will need to have the possibility to print both A4 and A3 papers. The benefits of the printer will be highest if it can print both A4 and A3. A drawing is hard to read on an A4 paper of that reason is A3 needed. Even if new technologies which generate the possibility to have documents in an electronic format increase, Brown, B and O'Hara, K [13] have found in their research that papers still are one of the most important component in mobile work. Of that reason I think a printer will be a useful component in a mobile office. A W.P. is clunky to have on an A3 paper, of that reason is A4 needed. Drawings and W.P. will probably be the most printed documents in the mobile office. Normally these documents are in black and white, so a black and white printer will be enough. When choosing a printer the size will be one factor, a small one with closed loader locker for A4 and A3 paper will be the best solution. The printers in the mobile offices should be contacted to the printer network at StatoilHydro. That will generate the possibility for the operators in control room to print out documents/drawings in the operators' mobile offices to the operators. Today the operators in the control room and the operators out in the process area of the plant support each other a lot and the mobile office should increase the possibility to supports, but decrease unnecessary time-consuming supports.

A place for the small human safe gas detector and its loader will be in a locker of the box. For the operators' safety it is great if the operators have the human safe gas detectors in their vicinity all the time in the plant.

Another locker in the box will be to place the gas detector, which is authorized to do gas measurements with, into. At Tjeldbergodden they use a gas detector model to do measurement with which needs to be calibrated in the administration building each night and therefore not need any loading station in the mobile office. The evolution of gas detectors run and it is hard to say that the gas detectors will look like in a few years. Therefore will this locker in the box be designed in away so different types of gas detectors and their loader can be placed where. One new type of gas detectors at the market today are IR-cameras with different filter for detecting different gases.

One old gnome in Swedish said: *"En bild säger mer än tusen ord"* (A picture said more than thousand words). The possibility to take pictures on problems and send to other operators, the engineers and the suppliers will generate easier discussions about the problems. Today than a small problem became found in the process area of the plant a notification is written. The notifications will later become W.P. If pictures can be added to the notifications the small comments about the problems will be easier to write and understand of other persons later in the working process with notifications. Therefore will it be an advantage with an EX camera located in the mobile office. To make it easier to send picture an easy loading station of picture from the camera to the computer are needed. A loading station of the EX camera is also needed in the mobile office. The possibility to load the camera in the car decreases the risks for situations with a camera without battery. Maybe it can be great with an extra battery in the mobile office for the EX camera, but that depends on the battery solution of the used EX camera.

7.2 Suggestion on Electrical Power Solution

One well know problem for mobile workers discussed in chapter 2.2, is to get power to the mobile office components. Of that reason will the solution to get electrical power has its own part in the concept suggestion of the mobile office in this paper.

Exact how much power the mobile office will need will depend on different factors as:

- The choice of laptop and printer
- How much the laptop will be used, in that cases where the energy consumption of the laptop differ a lot between used mode and sleep mode
- How much loading of different equipments which will be done in the mobile office

A power solution which mean only run the laptops and printers on batteries will take away a lot of advantages with the mobile office and do the whole idea clucky. A solution with batteries will take way the possibility to load the human safe gas detector and the EX camera in the mobile office, which are seen as good functions of the operators at Tjeldbergodden. It will also increase the operators' need of bringing in equipments for loading or bringing batteries in and out the office building to the cars. The mobile office need to be easy to use without a lot of extra work.

The battery in the cars will probably not cover the power needs of a mobile office. How much power it will be possibility to use from the battery of the cars will depend on how large part of the day the car will be on for travel and how long time each travel will takes. At Tjeldbergodden there are only two minutes drives down to the process area of the plant from the administration building. At a greater plant than Tjeldbergodden, which is a small plant, the drive times will be longer.

The power solution that this research will present is a solution with an external battery, which can be loaded both from outside and with power from the battery of the car. When the car is on, the external battery will be loaded from the battery of the car. When the car is off the loading process from the battery of the car will automatic be turned off, to avoid the risk of clearing the battery of the cars so start help will be necessary. The parking spaces where the cars will be parked for a while (half an hour or longer) frequently will have power loading stations. For example at Tjeldbergodden will the parking spaces outside the administration building have loading stations of power to the external batteries. The loading stations will have a design that only generates an easy action of the operators in plug in the power cable in a power socket in the cars. Where will also be a contraction similar to the fire truck power solution contraction at Tjeldbergodden (see Figure 7-3), which generate the possibility to drive away without manually plug out the cable in emergency situation and when the operators forgot to plug out the cable manually. Where are operators working at the plant all around the clock and that generate that the cars will be used all days (24 hours) with only short stops at the parking place. How may stops and how long stops depend on how well the equipment in the process area of the plant runs. Of that reason the external batteries need to deal a lot of short loadings. Maybe the external battery will not need to be loaded during every stop at the loading parking spaces. To generate information to the operators about the status of the external battery a visual battery status icon of the external battery will be implemented in the front seat of the car.

Figure 7-3 shows the two power construction on the fire trucks at Tjeldbergodden, which generate the possibility to drive away without manually unplug the power cable.

The idea with the power solution is to generate as less extra work to the operator as possible. The risk of generating a solution that include a lot of extra work is that the operators think it is not worth to have the possibility to use a mobile office.

7.3 Suggestion on a Wireless Solution

As discussed in chapter 2.2 broadband and wireless network are two technologies which have generated the possibility to make computer work as mobile work. The mobile office designed in this paper will need wireless communication to have the possibility to have access to the internet and in that way generate the possibility to make computer work as mobile work. At plants today, in the oil and gas industry, there are no wireless solutions out in the processes area of the plant.

One solution should have been a wireless plug-in dongle. The disadvantages with this solution are:

- StatoilHydro has high safety level on their data system and is not interesting of using wireless plug-in dongles as a standard solution
- The use of wireless plug-in generates the demand that a mobile office only can be used in areas which are covered by wireless systems. Today's wireless systems have not the possibility to cover all land based areas of different reasons, for example the topography. Plants commonly are located out of the civilisation in different types of topography
- Harder to connect the printers in the mobile office to the printer network at StatoilHydro

One new standard which increase in use and in research project today around the world are WiMAX. OLF (Oljeindustriens Landsforening) in Norway is doing researches on WiMAX at offshore installations in the BP's Valhall field [21].

WiMAX offer advantages which is useful as wireless solution at onshore plants. These advantages are, WiMAX can be used outdoors, indoors and mobile, for examples in vehicles as cars, trains and ships [25], see Figure 7-4. A mobile access point can switch between different bas stations without losing the connection during its travel in three different ways, Hard Handover, Fast Base Station Switching and Macro-diversity Handover [49].

WiMAX has the capacity to communicate over large distances with a high bandwidth. One of the ideas with WiMAX is that it should cover areas where other wireless solutions do not have the capability to cover. Onshore plants are commonly located fare from large cities, out in the nature, which can generate problems for the wireless systems. WiMAX can communicate in both LOS (Line of Sight) and NLOS (None Line of Sight) environments which is an advantage since the onshore plant usually are located in the nature, which can have hard topography.

Different types of aerials can be used in design of WiMAX systems, which generates the possibility to design a unique and special adapted system for each onshore plant.

A WiMAX network can be run in both license frequency bands and free frequency bands. The possibility to use WiMAX in a free frequency band decreases the costs a lot. It is expensive to buy and to own[5] a frequency band.

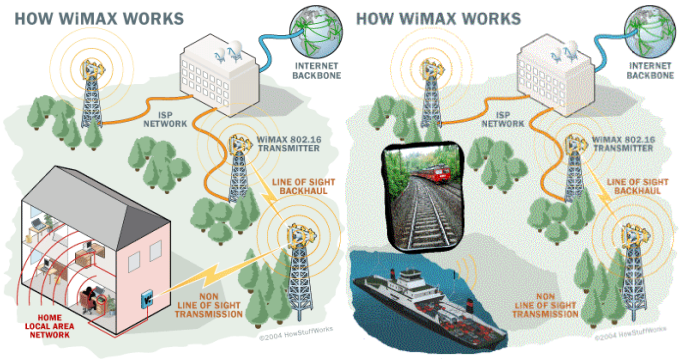


Figure 7-4 shows how WiMAX solutions can be designed, both outdoors to indoors and outdoors to mobile vehicles [20].

7.4 General Benefits of the Mobile Office

The greatest benefit a mobile office will lead to is less unnecessary travels to the office building. At plants today the office building is usually located beside the process area of the plant, how fare depends on the installation (from a few hundred meters to several kilometres). Today is the operators' office with computers, printers and other useful equipments as for example gas detectors and EX cameras located in the office building. This design of a plant result in that the operators today need to travel to the office building if they forgot drawings, documents, gas detectors etc, if they need of a specific drawing, document or gas detector emerge during their time in the process area of the plant or if they find error on the drawings, documents and a new copy will be needed. A mobile office as a complement to the operators' ordinary office in the office building will generate the possibility to print out needed document in the cars and have equipments that frequently are used in the process area of the plant placed in the cars. Frequently needed equipments can be gas detectors and EX cameras. Less unnecessary travels between the office building and the process area of the plant will generate more efficient working periods for the operators, less frustration from the operator who needs to travel one extra time and fewer cars driving which decrease the emission. Emissions affect the environment negatively. One of the HSE goals at StatoilHydro is *"to reducing the negative impact of our activities and products on health and environment."[46]*.

Today the operators in the process area of the plant use radio as their only communication medium. The persons who use radio at plants are limited to the operators in the process area of the plant, in the control room, in the office and in the workshop. If the operators in the process area of the plant need to come in contact with a person not using radio for example engineers and suppliers the operators need to travel to the office building, to either contact the person face by face, make a phone call to the person or send an e-mail to the person, or make a call to the control room

[5] When buy a frequency band, you first need to pay for buying it and when pay an annual payment for having the frequency band.

by radio from the process area of the plant and ask the control room operators go for the actual person. At StatoilHydro all employees have their own msn access. With a mobile office the operators will get their msn account in the cars. With msn in the cars the operators will get the possibility to communicate (by instance message, voice message or video conferences) with other employees in StatoilHydro without help from the control room and without making an extra travel to the office building. The operators located in the workshop make phone calls to suppliers when they discover errors on devices in the process area of the plant. Today they need to take notes about the errors and later make phone calls from the office building. For these operators it would have been an advantage with an IP-phone on the computer in the mobile office, so that they can make phone calls to the supplier directly when their knowledge about the errors is new. The possibility to take photos with an EX camera (located in the mobile office) and send to the called person will make it easier for the operators to communicate the problem to the other person and decrease the risk for misunderstanding. Even the msn function “start whiteboard” can make it easier to communicate about problems and decrease the risk of misunderstanding, because here the communicating persons have the possibility to make drawings and write text in the same window (shared in real-time). The radio will still be communication medium number one among the operators. The other communications mediums will cover communication areas which are out of the radios use areas.

Today two persons (at Tjeldbergodden) at the time with high knowledge about the plant have jour all the day (day = 24 hours). These persons have one jour phone each. With IP phone in the mobile office the operators in the process area of the plant can make calls to these two persons with the jour phones without help from the control room.

A faster communication among the operators, operators to engineers, operators to suppliers and operators to other persons will decrease the process times of rework errors in the processes at the plant. The possibility for the operators in the process area of the plant to themselves take contact with person not using radio with help of different communication mediums, as msn and IP-phone, in the mobile office, will decrease the communication by radio (sometime it is so much communication by radio, that it is hard to be allowed to speak), decrease the control room’s work in walking for persons (who the operators in the process area of the plant need to speak to) and increase the operators time out in the process area of the plant.

One of the operators work task is to control that every things in the process work well and sometimes they detect small errors, which need to be corrected later. The operators either take notes about the small errors or “save” the information about it in their head. Later when the operators enter the office building they will write one notification for each error. Most of the notifications will later in the process chain be W.P. The mobile offices generate the possibility for the operators to write their notifications direct from the process area of the plant. The EX cameras in the mobile offices will generate the possibility to add a picture as an attachment to the notification. Two advantages with writing the notifications directly are that the information about the errors are new (easier to write a correct and understandably notification) and the risk of forgetting to write a notification will decrease. With a

picture in the notification the text will be easier to understand correctly for the persons who process the notifications. Today it is sometime hard to understand several of the text notes in the notifications.

7.5 Benefit of the Mobile Office in the Process with a W.P.

Close to all works which are done in the processes area of the plant, in the oil and gas industry, need to be done with a W.P. The working process with W.P. are complex and a lot of acceptances from different persons are needed. The W.P. work as a safety barrier.

Today the working process with W.P. works in shortness as, one person writes a W.P. in SAP[6]. There are two levels of W.P, level 1 (work with high risk) and level 2 (work with middle risk), both levels can be divided into different groups. Each shift ends its working period by going through the W.P. that will be done activated during the next shift's working period, to control that the W.P. is correct written, if not they rewrite them. In this part of the process the W.P. will be moved from the state "Not accepted" to "Accepted but not activated" in SAP. To do this part of the process with an W.P. of level 2 it is enough if the shift leader signs with his/hers employee number. If the W.P. is of level 1 both the shift leader and an operator responsible for that part of the process in the plant need to sign with their employee numbers.

When it is time to start work after a W.P, the W.P. needs to be activated. The activation process of a W.P. in SAP can only be done by one person. From the activation part of the W.P. process also a paper copy of the W.P. have to be used. Today the operators in the process area of the plant make a call to the control room by radio and ask them to activate the W.P. in SAP. This "call" can take time if the control room has a lot of work to do. According to the rules the operators in the process area of the plant are allowed to activate W.P. of level 2, W.P. of level 1 - class A and W.P. of level 1 - entering by them selves in SAP. A mobile office generate the possibility for the operator in the process area of the plant to activate these by them self in SAP, without making a call and wait for help from the control room. This will decrease the communication by radio and the control room operators' work with W.P. At Tjeldbergodden close to 50% of all W.P. are of level 2, level 1 - class A and level 1 – entering. The numbers of the W.P. which are active at the same time are 10-40 at Tjeldbergodden. The work with deactivating and completing an W.P. work the same way as the work with activating an W.P. A mobile office will generate the same benefits in the deactivating and completing work as in the activating work.

It is possible to extend a W.P. of level 2. When extending an W.P. today the control room operators do it by pressing a button in SAP, and the shift leader and the operator, responsible for the part of the process need to physical sign the paper copy of the W.P. To use the mobile office in the work with extending a W.P, the today's system with W.P. needs to be changed.

[6] A well known data program in the oil and gas industry which handle a lot of processes and will presumable handle more processes in the future

7.6 How the Mobile Office Affect the Safety at the Plants

The mobile office may generate a large positive affect on the safety level at the plants, if for example a dangerous problem can be fixed quicker. One goal in StatoilHydro is to have as less persons as possible in the process, the mobile office can maybe affect goal negative. To affect the goal less persons as possible in the process negative, the operators choose to stay in the cars (larger risks for that when the operators have laptop with internet in their cars) instead of travel back to the control room when they did not have any more work to do in the process area of the plant at the moment. Today when safety is seen in a MTO perspective (the thinking behind the concept MTO is discussed in chapter 2.4), the organisations attitude can avoid that person wait for the next task to do in the cars instead of in the control room or in their office. As the humans' knowledge can avoid the risk of having person waiting in the cars in the process area of the plant. How much work the operators have to do depend on which time of the day they work (commonly more daytime than night time) and how well the processes in the plant run. When introducing the mobile office at a plant the introducing persons and the whole organisation must do it with an attitude that the mobile office only should be used to avoid unnecessary travel to the office building. When all works in the process area of the plant are done, the operators should travel back to the office building. The social factors among the operators in the team are important.

A not EX-certified laptop in a car can generate the risk that an operator bring the laptop into the process area of the plant which are an EX-zones. To avoid that the laptop is placed in the car with two safety barriers, one technical, which is a laptop locker, and one human, this is the operators' knowledge. To only have the operators' knowledge as safety barrier is not enough, humans can do mistake. A mistake which generate that none EX-certified components enter an EX-zones are totally unallowable.

One of StatoilHydro's points in the HSE list is: *"We are committed to reducing the negative impact of our activities and products on health and the environment"* [46]. With less travel with the cars at the plants the emission will decrease and as a result the negative impact on the environment will decrease.

7.7 How to Extend the Mobile Office to an Intelligent Agent

When having a mobile office in the cars, the mobile worker can do more mobile work. Of the reason that mobile offices include laptops with wireless connection, it generates the possibility to programming intelligent programs to be used in the cars as a help for the operators. On idea which has been discussed earlier in this paper is the idea of having a program which generates the shortest and most safe way to drive the cars when a gas leakage has appeared. If a PEAS table (discussed chapter 2.1.1) should be designed for this function, it may look like Table 7-1.

Table 7-1 present a PEAS table for an intelligent agent with will show the operator the shortest and most safety way when an gas leakage has appeared.

Performance measure	Environment	Actuators	Sensors
Safe, short	Roads, outdoors = windy, gas	Presented the way to drive on a display and by sounds	GPS, measurement of wind direction & wind's strongly, the position of the gas leakage

This program will only be a simple agent of the reason that it just will decide its result on the following parameters, the wind's direction & strongly, the actual position of the car, the goal position and the position of the gas leakage. Algorithms which can be used for programming this are TSP, ANT, SWORM etc.

Mattias Esbjörnsson [19] has done a study with road inspectors, who drive around on roads to find defects. He has developed a prototype "PlaceMemo". With the "PlaceMemo" the road inspectors could record sound messages about detected defects during their travels. The road inspectors sometimes did not have the possibility to stop because of the hard traffic to look at the defects, it can be hard to remember the defects and theirs positions. With the "PlaceMemo" they can play in a sound message about the defect during their travels and the "PlaceMemo" will connect it to the right position in the GPS. The next time the road inspectors will pass this place, the "PlaceMemo" will play up the message before passing the actual place to give the road inspector the possibility to stop in time.

With a laptop in the cars on large onshore plants, the possibility of designing similar as "PlaceMemo" systems increases. Large onshore plants in Canada are located in the forest. In this environment is it not only the process with can have defect even the roads. Trees can have fallen on the roads and beside the roads, which need to be fixed. If the operate not have time to do it directly a memory system to remember the place can be great to have.

7.8 Discussion and Future Work

This part of the paper will present reflection on the research together with suggestions on future work. The research question, *"How Can a process plant be more intelligent"*, was quite extensive. The thought before starting this research was that the process plant could be made more intelligent. But in what ways were hard to forecast and that did the research very interesting and gave the researcher the possibility to act in a creative way. The chosen methods generated a focus on humans and technologies interactions. During the research a deeper knowledge about the oil and gas industry was generated to the researcher. The oil and gas industry has high risk factors and that influence on all activities in every day's works according to the processes and the research projects. All these do the oil and gas industry real interesting.

At a process plants today the only technologies the operators in the process area of the plant have assistance from are, radio, pencil, pocket-book (to write in), W.P. (in paper format), drawings (in papers format) and the tools in their tool belts. In relation to which types of technologies humans in the western world bring with them every day, the world in a plant might seen little out-of-date to people not familiar with the oil and gas industry. The high risk factors at plants leads to that only EX-certified technologies are allowed to be in the process area of the plant. The EX-market is quite limited in relation to the not EX-market, for example the percent of computers and mobile phones which are EX-certified are close to zero. The need of wireless internet is still small at plants, but research projects which are dependent on wireless increase. Today projects are running on implementing of wireless network at plants. The wireless project which Tjeldbergodden is a part of said; before they will suit out a wireless solution for the process area of the plant they need good reasons to implement a wireless internet in the process area of the plant. As a first case concept of this research, a mobile office can be used as an example of that kind of benefits a wireless network can generate. Straight theoretically the concept of the mobile office can be developed when wireless has been implemented in the plant, because the mobile office does not need to be or include EX-certified devices. The cars are driven at roads outside the physical EX-zones and the technologies fixed inside the cars do not need to be EX-certified. The next step in the "development process" of a mobile office will presumably be to draw the concept of the mobile office in a 3D drawing program.

The plants have the possibility to be done as intelligent environments. Which level of intelligence may be discussed as said earlier in this paper (chapter 6.2), it depends on our view of the concept intelligent environment. The concept of a mobile office is a ubiquitous computing solution, but can later in the future be rebuilt to an intelligent agent which collects information about its surrounding, if the plant is designed in a way that make it possible for the car to interact with the equipment in the process area of the plant. A mobile office might be one step in the process of doing the plants more intelligent.

8 CONCLUSION

The purpose of this research was to study if the process plant in the oil and gas industry could be made more intelligent. The aim of this paper was to present the research done at StatoilHydro's research centre Rotvoll in Trondheim around the research question *"How can a process plant be more intelligent"*, with the onshore plant Tjeldbergodden as reference plant. The research was done by a master student with knowledge in subjects as artificial intelligent and ubiquitous computing, but without earlier knowledge in the oil and gas industry. The research started with literature studies and this paper presents background information about both the oil and gas industry and intelligence technologies. To found out if a process plant could be made more intelligent interviews and observations have been done.

Ideas on how to make the process plants more intelligent, in the ways that the solutions could help the workers were generated and presented in this paper. One of the first steps to make the process plants in the oil and gas industry more intelligent may be implementation of wireless network in the whole plant, toady it is only in the some office buildings. As Paula Doyle said during the wireless seminar (chapter 4.3.2), wireless is the future of intelligent environment. With wireless many system can be made mobile and new systems can be implemented without need of cable installation and in these ways generate possibilities for a more intelligent environment. One of the generated ideas for doing onshore plants more intelligent was a mobile office to be used in the cars which transport the operators around the plants. In the idea of a mobile office StatoilHydro saw high benefits and of that reason it was determined that the idea of a mobile office should be deeper analysed. The idea of a mobile office became evaluated for one stakeholder group, future users, and a concept solution of which equipments and software a mobile office should include and the design of the mobile office became presented in this paper together with a discussion about the mobile office benefits and how a mobile office will influence on safety at plants.

Some of the ideas presented in this paper will have had use of artificial intelligent algorithms such as:

- a map that guide the operators the shortest and most safety way (in real-time) when a gas leak appeared
- an algorithm which recommends an suitably stand-in operator when an operator in a shift team is ill
- image detection on views over the process area of the plant
- robots which can made the daily turn in the process area of the plant instead of the operators

The generated ideas in this paper show that a process plant in the oil and gas industry can be made more intelligent and shows that the answer on the head question in the research's question is yes; a process plant can be made more intelligent. The sub-question's answers, in what ways, are all generated ideas. Which levels of intelligence

the different ideas will generate depend on our view of the concept intelligent environment which has been discussed in this paper.

The idea which became evaluated, a mobile office, is a ubiquitous computing solution which will generate a lot of benefits to the operators at the plant, without any negatively influencing on the safety at the plants, if the safety barriers are followed. The main benefit of a mobile office will probably be time saving for the operators, the trips between the process area of the plant and the office building will probability decrease, how many have not been studied. Before the mobile office can be a reality the plants need to get wireless network. If a mobile office should be used in a plant not designed and build today, the plant can be built in a way that generate the possibility for the mobile office in the cars to both receive information from the control room, from StatoilHydro's databases and from equipments in the process area of the plant which the cars pass during their trip in the plant. (The research has only focus on how a mobile office could be used and designed for an existing plant.) By reflecting deeper in to the future about plants which not are contemplated today, more intelligent system can presumably be generated and confirm the answer on the question that a process plant in the oil and gas industry can be made more intelligent.

9 ACKNOWLEDGMENTS

When I started this research I did not know anything about the oil and gas industry and enter the research with a great interest of learning. During my master I have got theoretical knowledge in: intelligent systems/agents, ubiquitous computing, the used methods (litterateur studies, observations, interviewees, validations of ideas with stakeholder etc), knowledge about the importance of evaluating ideas with stockholders early in the processes and the knowledge that a smart idea is only marketable if it can generate benefits to the user. In this project I had used theoretical knowledge from the difference courses in my master program and predicated them in practise, which gave me good experience to bring with me into future works. I have got knowledge in the oil and gas industry and have taught me to see safety from more perceptives than technology. I thank all persons who have done it possible for me to do this instructive and interesting research, my mentors at StatoilHydro in Trondheim Vidar Hepsø, Amund Skavhaug and Dag Sjong, My contact person Hilde Hongset Gauslaa at StatoilHydro's onshore plant Tjeldbergodden, all operators at Tjeldbergodden who have introduced me in their work, all engineers located at different StatoilHydro office who have offered me information through interviews and all other persons who had support me in my work. Finally I will thank Mats Linger and Magnus Bergquist for their help in the completing phase of this research.

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APPENDIX 1

Questionnaire for the semi standardised interviews round one

The interview will start with a presentation of the interviewer, the research and the goal with the interview.

Then the interviewer will ask the interviewee a few introduction questions. After that it is time for main questions.

Introduction Questions:

- What is your name?
- How may years have you worked in the oil and gas industry?
- Which is your position today and which positions have you had earlier?
- Which platforms have you worked on?

The 5 main areas and their questions

A normal working day offshore:

- Can you describe a normal working day offshore?
- Which are you most common job assignments?
- Is it any differences in how a job assignment is done and the plan for how this job assignment should have been done?
- Does the time of year influences on yours job assignments?
- Do you need to check out or something similar when you start- and end a work day or take a break?
- How many hours is a working day?
- How many breaks do you have each day?

Communication:

- Which persons do you communicate with, in your daily work?
- What does the communication looks like between different parts of the platform?
- Which technologies do you communicate with in your work? (both intelligent and ordinary, sensors etc)
- How do you integrate with the technologies around you?
- Which language is spoken?

Accident and safety:

- What is included in the safety course which is needed to be offshore?
- Do you need to take any follow up courses, which?
- How you been in an accident?
- Which are the most common accidents offshore?
- What happened when an alarm starts?
- How commonly does an alarm start?

History

- How has the environment on the platforms chanced during your time, in the oil and gas industry?
- How have the changes influences on your work?
- Do you think the environment is safer today?

Differences between different offshore platforms and in contrast to onshore plants:

- Which are the differences between different offshore platforms?
- Which are the differences between offshore platforms and onshore platforms?

APPENDIX 2

The Robot at Sintef

Today where are no robots at platforms. Sintef is doing research with a Kuka robot and plan to do the first offshore test in 2015. The robot is programmed in a Kuka program that looks like assembler and BASIC.

Sintef's idea is to have at least one part of the platform free from people and instead install robots that make the work assignments. The robots will not have a high level of intelligence. The robots will be controlled of operators at the platform or on other locations somewhere in the world. On today's test station at NTNU, there are three IP cameras, one on the robot and two in the robot box. All three cameras take pictures/movies of the environment. The cameras are placed on a tilt sensor so they can record in all directions left/right/up/down/around and can be navigated of the operators. The operator got views from the cameras at computer monitors. As a complement to the IP cameras there is one thermo camera in the robot box, which also generates a view on a computer monitor to the operator. In oil and gas processes the temperature is an important parameter and with a thermo camera the operator can visually see the temperature of the liquid in the pipes. With a thermo camera the operator can also see if a person has entered the robot zone. The robot has position sensors in all bends so the robot can calculate exactly its position in the robot box. The calculated position errors are less than 1 mm. In the process area of the plant there are temperature sensors which wireless sends information to the work station of the operator. The wireless protocol that is used between the sensor and the base station is either Wireless HART or a protocol that can be upgraded to Wireless HART, have not come in contact with the person that knows that part of the project. But of the reason that Wireless HART is a new protocol and StatoilHydro will do the first Wireless HART test in May, it is probable a protocol that can be upgraded to Wireless HART. The base station communicates with the computer (PC) by MODBUS interface and TCP-cable.

The operator can tell the robot what to do for example make a general control, measurements on a specific device, open and close valves. The robot knows which equipment it needs for that specific operation. If the operator tells the robot to close an already closed valves, the robot will pick up the equipment and stop when it is time to close, because now the robot understand that the valves already is closed.

The robot can learn new actions during its lifecycle. That means the robot does not need to have all functions implemented before the installation part and start up process at the platform. One way to learn the robot new actions is that the operator has a robot arm in miniature connected to a visual robot at the computer monitor. The operator moves the miniature arm and can see the movement of the visual robot at the monitor. This movement can later be transferred to the real robot. The other way is that the operator steer the robot with a 3D joystick. But nothing is allowed to go wrong. The robot is not allowed to clash into the equipments of the process or in to other robots. When the operator learn the robot now actions (independent on in which

way) the robot is always calculate so it does not enter a not allowed position, before it accept the new action/position.

The next thing sintef will implement on the robot is a camera which can generate 3D views. With that camera it will be easier to steer the robot.

At Sintef on NTNU, where the robot is placed, the operator work place is placed direct outside the robot box. But Sintef has done experience where an operator in Oslo was controlling the robot in Trondheim and that worked well.

APPENDIX 3

Questionnaire for the semi standardised interviews round two

Organisation, location and Transports

- Can you describe what the plant you have been working on look like, both geographically and organisationally?
- Did you need an "enter card" to pass between different parts of the plant, as at Rotvoll? If yeas, between which parts?
- Did all workers have their own working places (even the operators)? Are all worker places located in the same part of the plant? Did any workers have their working place in the process area of the plant?
- How did you transfer between different parts of the plant? Did you use any transport vehicle, at Tjeldbergodden cars are used? If a fuel drive vehicle was used, what type of fuel does the vehicle drive on?
- Did you need to pass many stairs and elevators in you work?
- Do you think the transport was a time-consuming part of your work?
- When you needed to found a sensor/device etc in the plant, which help system do you have help from? (tag-number, 3D views etc)
- Do you think it is hard to found the sensors/devices/etc in the plant?

Job assignment – what is done, by who, how can it be affected

- Can you describe your job assignments at the plant?
- Where in the plant did you do your job assignments?
- How did the weather influence on your work any time? How?
- How does the process technician's work differ from an engineer's work?
- Which tasks are done in the process, both daily job assignments and temporary? Are there offices located in the process for these works? Are there any working places for these assignments in the process?
- In the control room a lot of monitors are located, can you say something about the information on the monitors?
- What does it look like when an alarm starts in the control room? (In the same way as at Tjeldbergodden?)
- How common is production stops? From "*Oljeriket*" I heard that a production stop was required to solve a problem with the flare.
- At platforms some types of equalisation need to be done night time, what?

Communication – different ways in communication

- How is the communication done on the plant? (Any other way than radio?)
- Between which workers and parts of the organisation how are the communication done? (Other ways than control room – operator)
- Who is communicating with the ships in loading processes?
- How is/was the communication done between equipments and workers?
- Was it any wireless communication during your time at the plant?

- Is there any places at the plant, where the noises are too high for having a direct conversion between two persons? How does persons do work together in theses areas with high noise?
- Was it any speakers at the plant you worked at? For what?
- Is the phone number 100 a common number to call if an accident appear or is it specific number for Tjeldbergodden? Which phones are used to make call on in the process?
- An earlier interviewee talked about radio-room are there any? Can you say something about the radio-room?

Equipments and fact about the process and alarm

- Which equipments, measurement devices etc do you came in contact with during your work at the plant?
- Which were the most common errors and alarms during your time at the plant? Do you think that these are the same today?
- How do they handle P&ID at the plant you worked at?
- Was surveillance cameras used at the plant? If yeas, for that? Was it possible to steer the surveillance cameras from the control room?
- Was IR cameras used at the plant? If yes, for what?
- How you experiences from the lookers, which get together all signal from measure instruments before sending their value's to the control room? Which experience?

Safety

- During your time at the plant, where you in any specific emergency team? If yes, which? Can you say something about it? How often do you train? (example fire patrolman)
- Were equipments to use in an emergency situation of any type located at the plant?
- Did the safety increase during your time at the plant? If yeas, how?

APPENDIX 4

Other ideas which became generated during this research

This appendix has no relevance for the content of this paper. This appendix includes ideas which have no relation to the idea about using the cars to do the process plant more intelligent. The only reason for having these ideas here is to save them for the future, of the reason that they maybe will be of interest for StatoilHydro.

Ideas and findings that do not have anything to with cars are:

Ideas and findings connected to the jetty and ships:

- The jet office could be placed closer to the jetty and have a great window towards the jetty. That will give the operators the possibility to bee in the jet office, doing work, and at the same time have the possibly to surveillance the loading process in the jetty
- Why have a debarkation (to large for use) placed in the jetty, when it never is used. One of my learning from the safety course is to have as many free areas as possible in an hazard environment
- Have equipments to lift the heavy pipes with. The heavy pipes are used in loading to supply ships
- In the loading process of ships a lot of papers need to be filled in, signed and printed. Would it not be better to use computers more?
- A colour printer or a printer with more than one paper loader should be good to have in the jet office. To use when print papers which needed to have the StatoilHydro's logo (only some are needed). Today this is done in two steps, first print out the papers and then copies them to a paper with StatoilHydro's blue logo on.
- A small and user friendly program that calculates the methanol price for the operator, today it is done on a simple calculator. A program for that can easy been done in for example Matlab

Other idées:

- Demand that all persons who work in the plant use radios. In external teams (that do services in the processes) it is common that only one in the team use radio and they can be at different locations in the plant. That is a problem for the shift/control room when they need to contact all workers in the process
- One operator said a new fire truck with a larger engine, but I think this was a not serious idea
- Today when one person is ill in the shift team and the shift are not able to cover all positions without the ill person and a stand-in is needed. When calling in a stand-in it needs to be a person that covers the knowledge gap in the team. (Knowledge about the missing part of the process, has the missing certification apprentice and the missing position in the emergency team) I do not know if they have any automatically system that generates possibly stand-ins, but it can be made with an **AI algorithm**

- Monitors at different places around the plant, which have the same views as in the control room. The operators would like to have a better overview of the plant even out in the field
- Today when for example a pump should be started, the operator out in the process need to do some of the preparation and the operator in the control room need to do the other part of the preparation and the start up. The two operators' assignments are in most cases synchronised and communication is over radio, to do all preparation in the right order. Sometimes the pumps do not start as they should because of misunderstandings over the radio. Here it should have been great with a shared real-time at to do list and functions that only "allows" the operators to do all things in the right order
- I read about the smoke-driver simulator *"sidh"*, in the Swedish technology newspaper *"Nyteknik"* number 14. Maybe it can be something for the smoke-driver at Tjeldbergodden and other plants
- Use of automatic control of the content of the camera views, I think this will be useful in the future. One algorithm that can be used for that is **artificial neural network**