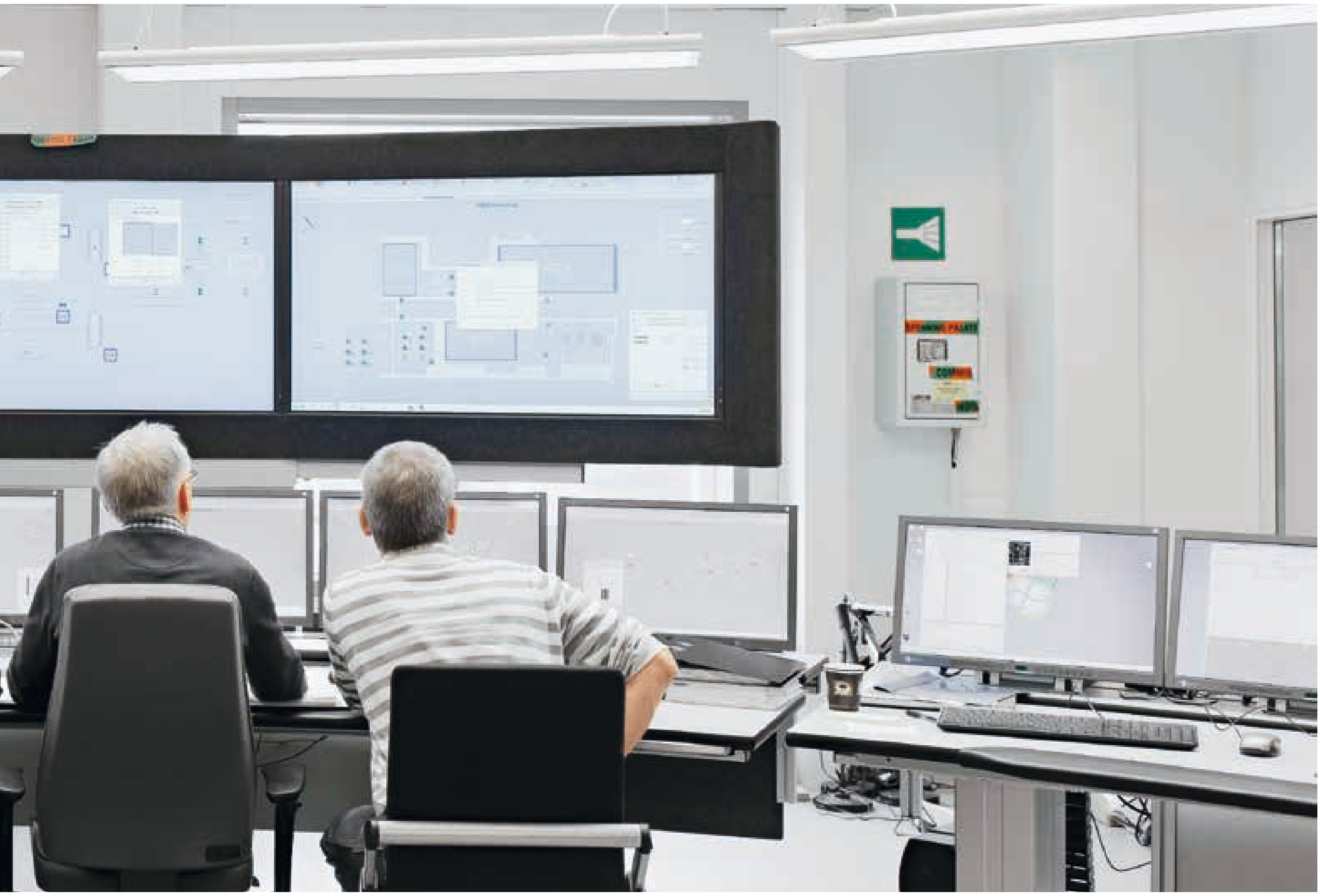
Understanding your user

Ethnography helps deliver better operator interface displays

KRISTOFFER HUSØY, TORGEIR ENKERUD, TONE GRETE GRAVEN – Ever since the Three Mile Island incident, increased attention has been paid to the design of human-machine interfaces. This has led to extensive research in areas such as system design for increased situation awareness and alarm management – and consequent improvements in control system user interfaces. It has also resulted in the emergence of standards and guidelines such as ISO 11064 and EEMUA 191. A focus on the human-machine interface and operator effectiveness is essential not only to ensure safe operation, but also to enable more proactive, and therefore more efficient, production. At the same time, especially in the oil and gas sector, a continuing strong drive towards remotely-sited control rooms and more cost-efficient operation is steadily introducing ever more complex processes and automation that require extensive access to real-time data. These changes impose demands on the designers of operator interfaces. To help tackle these demands, ABB has turned to ethnography-based system design.



Ever since the dawn of the industrial revolution, great ingenuity has been employed to keep the machines that man has devised under control. The engineers in the early days would undoubtedly have wished for ever more dials and levers in their human-machine interface (HMI), but few of them would have foreseen that, in less than two centuries, the steam engine, say, would evolve into the staggeringly complex engine that is a power generation plant. The control demands of such modern installations are fantastically more sophisticated than those of their predecessors. However, modern network technology facilitates the control of such giants by making vast numbers of measurements available in real-time at remote support centers. Some complex facilities can even be controlled remotely via a laptop computer. Unless development in the area of human-machine interfaces is able to keep up with this growing system complexity, the challenges relating to information overload and intricacy in control room operation are likely to become overwhelming. Operator interface design is, therefore, a critical aspect for the safe and effective operation of a modern industrial plant ➔ 1.

Title picture
Control room operators are in charge of ever more sophisticated plants. How does ethnography-based system design help simplify their task?

ABB's Extended Automation System 800xA, generally considered to be a user-friendly and effective DCS (distributed control system), provides the user interface for many ABB products. To ensure that this interface keeps up with the requirements of even the most complex installations, it is essential to have a deep understanding of the user's current needs and challenges and an insight into future trends. To help achieve this, ABB has introduced ethnography-based system design ➔ 2. By observing firsthand the pain points and day-to-day challenges experienced by novice and expert operators, system designers can tailor future operator interfaces to suit the actual challenges likely to be faced.

The user guides

User-centered design (UCD) methodology – a vital area of research within the software engineering community – postulates that the user must be a central part of the development process, and that a broad and deep understanding of the user and his needs must be acquired early on. The Google search engine, the Amazon website, Microsoft Windows 7

Unless HMI development keeps up with system complexity, information overload in control rooms may become overwhelming.

Ethnography-based methodologies pave the way for game-changing innovations and improvements of control operator effectiveness.

1 The design of the operator interface of complex plants is becoming ever more critical.

and the Apple iPod and iPad have all benefited greatly from such UCD processes. Process control HMI products can also benefit from this focus on the user. However, the process control scenario must be approached somewhat differently as obtaining test personnel and setting up a realistic test environment in complex and time-critical process control situations can be prohibitively expensive and may even be entirely impracticable. This is what led ABB to employ ethnography-based investigative techniques, which are part of the UCD methodology, as a strategy for obtaining a broad and deep understanding of the DCS end-users. By building on knowledge of human factors and situational awareness, and by adapting UCD in this way, ABB has broken new ground in terms of DCS operator interface design methodologies ➔ 3.

Currently, local knowledge of the physical plant being controlled is a necessity.

The methods call for the system designers to observe operators as they perform their normal business in their normal working environment. In this way, the designer can see, firsthand, how operators use the system and what the major and minor difficulties are. It is a key prerequisite that the operators are observed in their normal environment as this allows the observer to obtain detailed accounts of how work is accomplished in practice, rather than how it may be specified, or how workers might report their actions in an interview.

This type of study can be tailored to either gather requirements for improvements to existing solutions, or to collect information that can inspire new solutions. The following discussion summarizes some key findings from a series of ethnographic studies performed by ABB at five oil and gas sites in Norway and India. The sites were: An offshore oil production rig, three gas processing facilities and one oil refinery. They spanned the spectrum of older sites, older sites with major new additions, relatively new sites, and one brand new site that was still partly undergoing commissioning. Two to three researchers visited each site, and spent three or four days in the control room observing the operators at work, and, when possible, encouraging them to speak out loud as to what they were doing and why.

2 Ethnography

Ethnography is a qualitative research method aimed at learning and understanding cultural phenomena that reflect the knowledge and system of meanings guiding the life of a cultural group. Originally pioneered in the field of socio-cultural anthropology, it has also become a popular method in other fields, such as the one described in this article. There are many practical applications of ethnographic methods in commercial contexts, particularly those that involve technology and workplace innovation. Data collection is often done through participant observation, interviews, questionnaires, etc.

3 User-centered design

User-centered design (UCD) is a design philosophy and a process in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design process. The chief difference to other product design philosophies is that UCD tries to optimize the product around how users can, want, or need to use the product, rather than forcing the users to change their behavior to accommodate the product. [1]

User-Centered Design methodology postulates that the user must be a central part of the development process.

Local hero

Currently, local knowledge of the physical equipment being controlled is necessary. The control system's graphical user interface normally implements a high level of abstraction in how the process is presented to the operator in order to remove superfluous detail and highlight crucial information ➔ 4. However, this comes at a price, namely that the operators need to have significant practical experience of the equipment they control. At all the sites visited, the control room operators were required to have prior experience as field technicians and several sites also required them to regularly take shifts as field technicians in order to keep their process knowledge fresh ➔ 5. With the advent of centralized and remote control rooms, one cannot rely on this level of detailed knowledge, so essential for safe and efficient operation, being present. Building up and providing local knowledge is, therefore, a critical aspect that must be catered for when control operators are situated away from the actual plant.

Normal operations involve a high degree of multitasking.

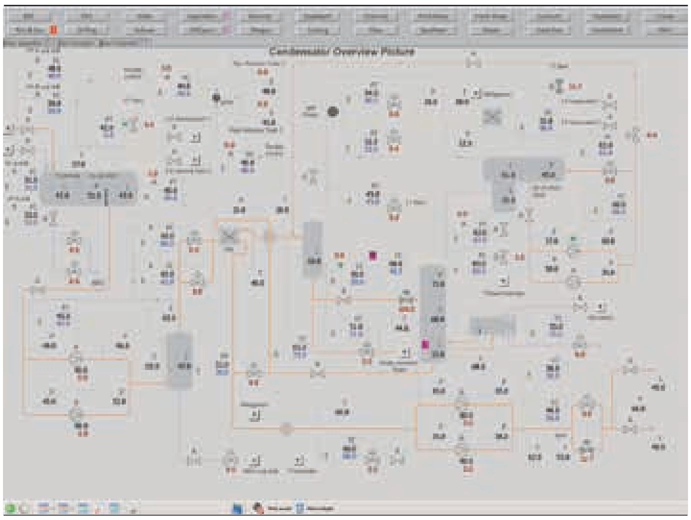
Busy bodies

At all the sites visited, normal operation involved a high degree of multitasking. The operators were continuously engaged in a multitude of parallel tasks that needed attention at irregular intervals. For example, while keeping an overview of the overall plant performance, an operator could be filling a storage tank, starting up two new wells and supporting a field operator in testing gas detectors. In addition, there are many ongoing tasks in the plant in which the operators are not directly involved, but which can be relevant for current or future process decisions. For example, there could be equipment that has been taken out of production for maintenance purposes for a limited time. The operators employ different aide memoires, such as notepads or manual stop watches to remind them of ongoing work tasks. This plethora of activities also involves significant parallel communication and collaboration with different internal and external parties. DCS user interfaces should, therefore, provide ample opportunity for the operators to be able to cancel or postpone operations effectively and smoothly. Some operations are naturally difficult or impossible to postpone due to process constraints, but the current design of the automation system imposes unnecessary constraints on the operators.

In MPC we should trust

Advanced control strategies such as model predictive control (MPC) have been employed at many industrial process sites over the last decade. MPC is a control strategy that utilizes a model of the process to predict how the plant will react to the current input. It is a robust and accurate control strategy that normally performs better than traditional PID control. However, one major challenge with MPC is that it can be difficult for the operators to understand how it works. This reduces the operators' trust in the system and several instances were

4 A typical process graphic, of which there can be thousands



5 Operators need a local knowledge of the plant in order to understand abstract HMI displays.

To improve operator trust, better interfacing with MPC and other advanced control systems is indispensable.

observed where operators switched over to manual mode to steer the process back into a more stable state, before handing control back to MPC. It was clear that they were not comfortable with the course of action being undertaken by MPC.

Even if an advanced control system, like MPC, has a state-of-the-art user interface, operators can still have problems understanding the information presented to them, and they may, therefore, prefer to resolve an issue by switching to manual control, rather than by adjusting parameters to steer the system. Although MPC is a powerful tool for optimizing production, its full potential can only be realized if the collaboration with the operators works effectively and human and system work together as a team.

Alarm processing

A large part of the operators' responsibility is to detect and handle faults and disturbances that occur in the plant. Due to the vast amount of information available and the complexity of the processes, the operators are not able to supervise all parameters at all times. The alarm system, therefore, remains an invaluable tool to detect abnormalities in the process.

At most of the sites visited, incoming alarms continually interrupted the operators' work. The majority were immediately recognized by the operators and acknowledged without any further action. These alarms were mostly due to some known equipment fault or ongoing maintenance work in the plant.

When an alarm was unexpected or unknown, the operators' first response was often to question whether the alarm was related to ongoing maintenance work. After eliminating this cause, the operator would normally move straight to the relevant process graphic to find the exact location of the fault and make a quick estimate of possible cause and consequences. Experience and a good knowledge of the plant topology were then essential for a rapid and accurate evaluation of the situation. Problems were often resolved by referring to successful strategies employed in similar situations in the past.

A second approach was to inquire whether anybody else in the room, or on the radio, had ever seen similar behavior before. If so, the operators would often test or apply the previous solution. Only if the process did not respond as expected would they start to evaluate the situation in more detail, or start looking for a procedure related to the equipment in question. Again, this behavior revealed a heavy reliance on the operators' local knowledge of the plant for safe and efficient operation. When moving towards centralized and remote operations, the system itself will have to provide better support for interpretation of unfamiliar alarm situations.

6 The use of ethnographic studies will increase as industrial systems become more complex and control requirements more sophisticated.

Tying it all together

For any type of software product, it is important to have a solid understanding of the user's role, the intended functionality and the context of use – in other words, a deep insight into the real-life circumstances under which the product will be used. Ethnographic studies gather and structure this type of information.

Having this information gives the development team direction and guidance in making well-founded design decisions, and it increases the probability that the product will be effective in helping the users reach their goals. For DCS development, these factors are particularly important as the context of use is both complex and safety-critical.

The information also makes it possible for the designers to pinpoint areas where a new solution has the best potential to improve operator effectiveness, enable better operational regularity, improve safety aspects and ensure optimum production.

It has been seen that localized knowledge and experience is essential for safe operation of the plant and a need to make experience data and physical information directly available from the user interface has been highlighted. Similarly, it appears that further development regarding visualization and interfaces for advanced control systems is needed to improve operator-system collaboration.

> Ethnography-based methods call for designers to observe operators performing their normal business in their normal working environment.

All in all, ethnographic studies can greatly enhance the effectiveness of HMI design and it is foreseen that their use will increase as industrial systems become more complex and control requirements become more sophisticated → 6.

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Reference
[1] User-centered design.
Retrieved April 14, 2012 from
http://en.wikipedia.org/wiki/User-centered_design