Spatial awareness

3D representations improve situational awareness for control room operators

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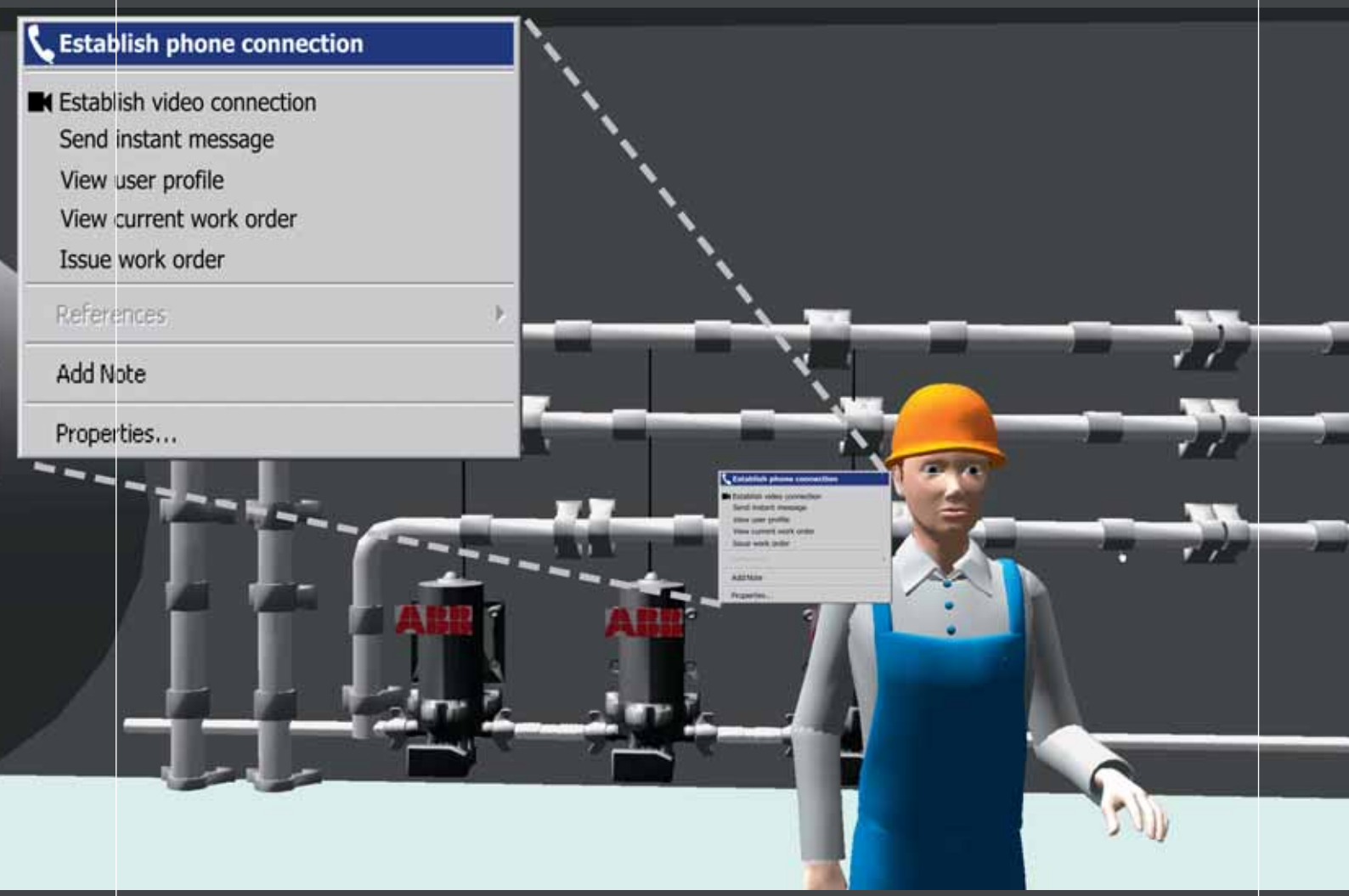


Progress in both computer power and control algorithms are permitting computers to handle increasingly complex tasks in process control. What then, is the future for control room personnel? The scenario of the computer having the control room to itself is unlikely in the foreseeable future – the human ability to think creatively, exercise judgement and improvise remains unrivalled. However, control room personnel are moving into positions requiring a broader overview. As a result, operators have less detailed knowledge of the plant. Staff effectiveness is increasingly depending on the method in which information is presented to them.

ABB is developing a three-dimensional representation for the oil and gas sector. The operator can see inside the plant and gain an overview of what is happening inside. The 3D view also aids communication with field personnel, as both see the plant in the same way, so reducing the risk of misunderstandings leading to incorrect actions.

Today's industrial processes are controlled by human operators, who in turn are supported by industrial control systems – a situation that is unlikely to change in the foreseeable future. In spite of rising levels of automation permitting reductions in manpower and hence operational expenses, the unique creative and problem-solving capabilities of humans will remain indispensable at the control desk for many years to come. This means that operators and automation systems must continue to monitor and control such processes in collaboration. A clear and efficient communication between the two parties remains a prerequisite for the optimal functioning of industrial processes.

This is the basis of an ABB research project in Norway, focused on the needs of oil and gas plants. In such installations, the control system needs to display information in a clear and intuitive manner to let the operator do what she does best: interpret information, solve problems and be creative. When the control system presents its information in a manner that is well suited for human interpretation, the operator can digest more information and grasp what is going on more quickly.

Operators in control

The overall safety and operation of a plant relies on human operators being in control and playing a decisive and indispensable role in overall plant operations. Today, processes are mostly controlled from a central location – the control room. The operators in the control room are responsible for the day-to-day monitoring of the process. This involves making key decisions such as setting optimization levels for the process, scheduling maintenance and responding to critical alarm situations.

When the control room operators are located away from the plant, they will not be able to maintain detailed knowledge of physical locations and spatial relations of the plant.

But the operators in the control room do not run the plant by themselves. They rely on personnel in the field. These field operators are the hands and eyes on the plant floor. Their activities include operating, configuring and calibrating the equipment, as well as performing maintenance and service operations in conjunction with the dedicated maintenance and service teams. Furthermore, the process engineers, instrumentation engineers, remote experts and administrative personnel also play a role in the daily operation.

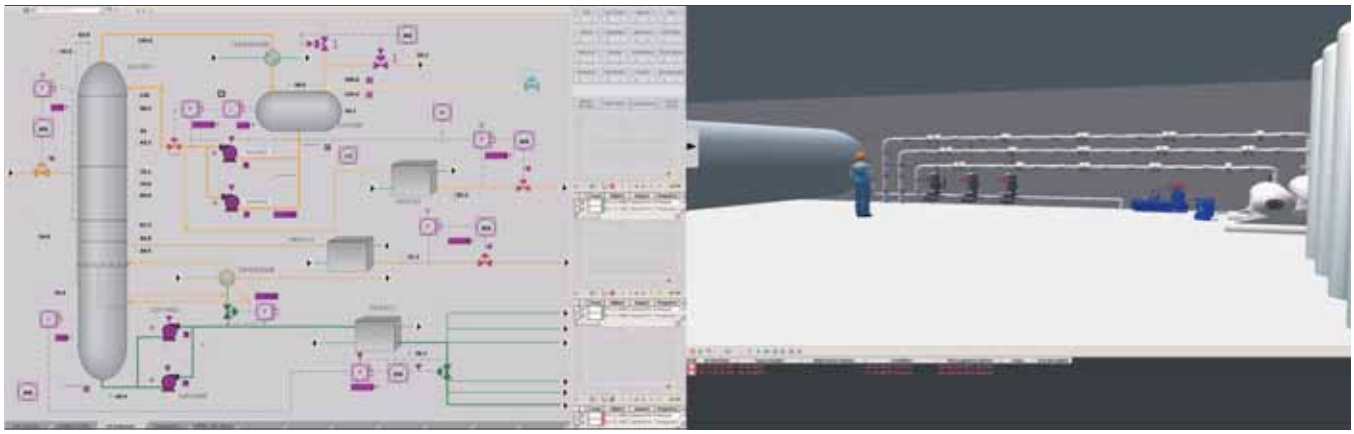
The overall performance of the plant is dependent on all systems and actors performing well together. This collaboration can take the form of co-located collaboration, or remote collaboration. In co-located collaboration the process control operators, field operators and managers come together to discuss problems and plan operations. Examples might be shut-downs, start-ups, maintenance schedules and optimization issues. In remote collaboration, the on-site personnel collaborate with remotely located personnel – either field operators or remote experts. For example, when maintenance is performed in the plant, the process control operators and field operators work together to ensure that the operation is as safe as possible. The process control operators make sure that the equipment is properly sealed off and aid the field operators in their maintenance task.

Both of these scenarios require close collaboration between individuals with different domains of expertise and often with different cultural, technical and social backgrounds.

The future is coming

Looking ahead, several trends can be identified that will have an impact on the control room operator's situation and role. The principal among these is the centralization of control rooms, which has recently been pushed by the demands for higher profitability, cost reduction and safe and efficient operation. This trend – often referred to as "Integrated Operations", "eFields" or "Fields of the Future" in the oil industry – will have great impact on the way industrial plants are controlled in the future.

Tight integration of the traditional operator interface with the proposed 3D interface is crucial to enhance efficiency and support operator's situation awareness



When the control room operators are located away from the plant, they will not be able to maintain detailed knowledge of physical locations and spatial relations of the plant. This might lead to field operators becoming the only personnel with detailed location-specific knowledge, whereas control operators take over more administration and optimization related tasks. This trend will also probably lead to one control room operator controlling larger plant areas or even several different plants.

The operator can navigate around the model, investigate details, get an overview and clearly see the physical and spatial relations.

Furthermore, there is a tendency for oil companies to want suppliers to be responsible for equipment and subsystems through service agreements to a larger extent than before. The suppliers – such as ABB – will not want to place personnel at all sites, but rather monitor and control equipment from a central location. This will require the suppliers to have access to relevant, live, on-line data from the plant, and efficient means to communicate and work together with onsite personnel.

Finally, there is a clear tendency for advances in instrumentation and measurement systems, computing power and network capacity to produce greater amounts of data. Not only will such data be transmitted more frequently, but there will be more sensors transmitting it to the control room. This will lead to even more data being fed into the control room, with increased risk of information overload.

The human perspective

Interpreting these tendencies, the trend towards minimizing the number of operators remains, but it is neither realistic nor desirable to wholly automate such processes. So, for the foreseeable future, human operators will remain in control and will depend heavily on their ability to communicate with the automatic parts of the control system. When looking at this from the human perspective, a range of interesting implications for a control system supplier such as ABB becomes evident:

Support operator's situation awareness

The operator must understand the state of the plant at all times. This means the operator needs to get the right information, the appropriate amount of information and most importantly, the information needs to be displayed in a manner that the operator can assimilate and can react to.

Ensure optimal allocation of tasks between operator and system

There should be a conscious decision in selecting the tasks that should be handled by the operator and those that should be automated by the system. One perspective on this choice is that this decision should be based on an understanding of which of these can perform the job best. In this manner the performance of the system, including human and computer, can be optimized. This holds that the tasks allocated to the human operator match human abilities, and that the computer handles the tasks it is best suited for Factbox.

Support remote and co-located collaboration

As described above, there are many parties that contribute to successful plant operation, and it is important to support collaboration between them. This means the collaborators need access to the same information; they need to be able to share information and they need to get an understanding of each other's situation and context.

The physical limitations of what a field operator can and cannot do, the physical relationships between different objects and the location of components are immediately and intuitively understood when viewing a 3D representation of the plant.

3D visualization to the rescue

A research project in ABB Oil & Gas Norway is currently investigating how a 3D interface of the plant and process can remedy the problems described above. The idea is to use 3D models of the plant and all equipment in the operator interface. The 3D models are assembled with correct dimensions compared to the real plant layout, and the 3D models are tightly linked to the corresponding control system objects. The operator can navigate around the model, investigate details, get an overview and clearly see the physical and spatial relations.

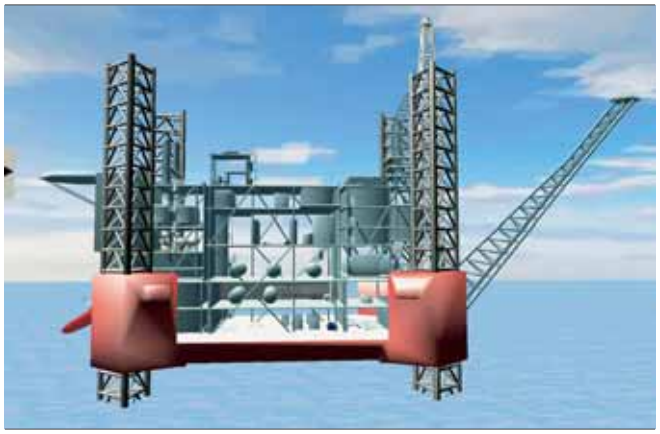
So what benefits does the introduction of the new dimension offer? A 3D interface is life-like, and hence easy to recognize. It shows relations and dimensions in an intuitive manner, and is well suited to the human mind. Humans are accustomed to perceiving objects, remembering locations and relations and orienting themselves in three dimensions. Even more, we are actually very good at it. It is more efficient to display complex information in three dimensions compared to traditional presentation techniques.

The advantages in using 3D models of the process and plant for operator interfaces in industrial control are apparent. By augmenting the process

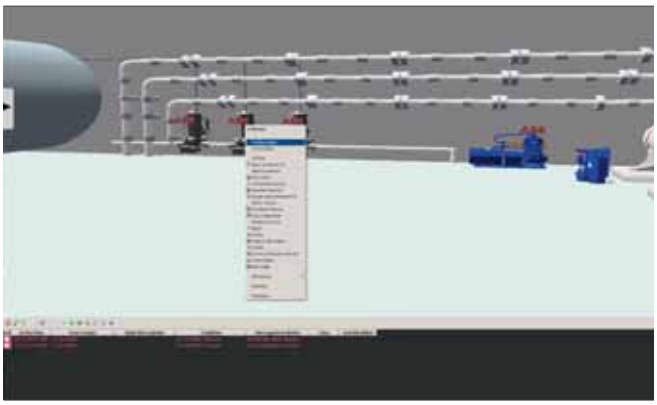
Factbox showing the strengths of humans and computers in decision making, based on Fitt's list.

Humans are better at	Computers are better at
Perceiving patterns	Responding quickly to control tasks
Improvising and using flexible procedures	Repetitive and routine tasks
Recalling relevant facts at the appropriate time	Reasoning deductively
Reasoning inductively	Handling many complex tasks simultaneously
Exercising judgment	

The 3D model provides an overview of the location of objects, personnel and other spatial considerations



Interaction with objects can take place in the same manner as in the traditional operator interface. The context menu gives access to all aspects of the component



control interface with a 3D-interface, many of the problems mentioned above can be overcome. The operator can get a better understanding of the situation, can be relieved of the mental stress of trying to understand the situation or remember the location. A 3D representation can simplify collaboration. The physical limitations of what a field operator can and cannot do, the physical relationships between different objects and the location of components are immediately and intuitively understood when viewing a 3D representation of the plant. The operator does not need to have been on site or have to remember in which area the component is located. The interface shows it plainly and unambiguously.

The operator must be able to switch effortlessly between the two representations to select the one which is most appropriate at that moment. There are distinct advantages in both interfaces that need to be clearly understood and taken advantage of.

Furthermore, if the position of the field operator is known, for example through some tracking method, the advantages are even clearer. There is no longer any need for the operator to explain what she sees or where she is – such information is displayed precisely by the interface. Explaining one's exact position is not easily done on the walkie-talkie, especially if the control room operator or remote expert is not familiar with the location. When a critical situation arises, the seconds saved by this clear understanding of the situation can be of great value. More importantly, the chance of a misunderstanding is drastically reduced. As the control room operator can clearly see which component the field operator is facing, mistakes such as spelling mistakes or misinterpretations are much easier to detect.

The traditional process graphics cannot be done away with, nor is this an objective. A tight integration between the traditional process graphics and the 3D interface is crucial. The operator must be able to switch effortlessly between the two representations to select the one which is most appropriate at that moment. There are distinct advantages in both interfaces that need to be clearly understood and taken advantage of. For example, the traditional two dimensional interface is effective for showing a simplified and structured overview, while the three dimensional interface is better for seeing relations and understanding physical aspects of the process plant. A 3D environment is also better suited for navigating in large information spaces – a challenging task for the control room operators. Navigating between process graphics is a tedious task today, but the operators depend on being able to find what they are looking for quickly. By better supporting spatial awareness and providing efficient movement between distant locations, navigation can become natural and lightweight so that users can focus on solving the problem.

So, how distant is this future? ABB has developed a concept prototype that works inside the System 800xA framework. This is a necessary step to get valuable feedback from operators, customers, and internal sources. Understanding the true benefit of 3D interfaces can only be achieved through real-life testing and experimental investigation. The preliminary results show improved interaction for many of the problems faced by today's control room operators.

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