Hauptbeitrag

Process Operation 4.0

Collaborative operations in highly digitalized integrated work environments

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Digitalization, Internet of Things, Big Data, Artificial Intelligence and Virtual Reality are some examples or rapidly developing technology areas with high impact on how industrial processes will be operated in the future. Normal operation usually is already highly automated and will be even higher automated in the future. Tasks like fault detection, diagnosis and process optimization are getting more complex. Many of those tasks can be best handled by interdisciplinary teams with broad expertise and knowledge about process, plant, operations, maintenance, networks, sensors and actuators. Collaborative Process Operations allows to efficiently bring multiple disciplines together and jointly focus on the problem at hand. Big Data and Artificial Intelligence tools support teams and make them as efficient as possible. Previously isolated control rooms become networked control centers for the Industry 4.0 high performance work force. Work environments must support collaboration at all levels and support high performance work around the clock.

Keywords: Collaborative work environments, Digitalization, Industry 4.0, Operator Effectiveness, Productivity, Safety

1 Introduction

Similar to the situation in transportation with the upcoming self-driving cars, the way industrial processes are operated is dramatically changing. Today's sophisticated digital automation programs are able to handle most of the normal and even many of the abnormal situations. Cheap sensors in connection with powerful artificial intelligence algorithms like image recognition or vibration monitoring can replace more and more human sensing. A single operator can take responsibility for larger and larger plant sections.

Integrated industrial information systems gather operational data to enable collaboration across locations, disciplines and organizations [1]. They make real-time data easily available to the appropriate persons.

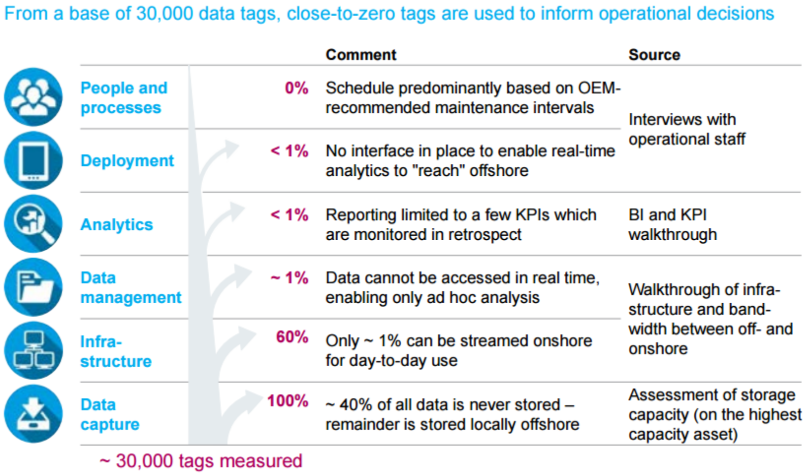

Figure 1 Case example about data-driven decisions [source McKinsey]

However, today's reality is often far from ideal. In a case example about offshore platforms, McKinsey [2] has shown that although huge amounts of data are already being collected, only a small portion is actually being used as a basis of operational decisions. This is currently changing as the technical infrastructure which allows to make data-driven decisions, becomes available.

Other important trends are flexible modular plants for producing small quantities of frequently changing products [3]. Such processes are more difficult to operate because of the frequent product changeovers and it is more difficult to build up experience.

New Big Data and Artificial Intelligence methods can predict upcoming problems long before they affect production, and enable prescriptive maintenance strategies.

Remote operation is becoming more widely used. Often it makes sense to bring in highly specialized expertise from remote and sometimes even the whole plant is operated remotely, as is the case for many offshore platforms.

Modern control rooms have turned into networked information and communication centers where collaboration workflows come together. The remaining operators need a work environment that supports them in staying vigilant and carrying out their jobs as performant as possible [4].

2 Data availability breaks down information silos

Modern process plants are complex and highly coupled systems. A consequence of this is that a problem occuring in one part of the process will tend to propagate across different sub-system and plant components. The advanced automation systems in use also add complex dynamic interactions between the different plant components, making it difficult to obtain a clear assessement of a potential problem. Collaborative efforts of a multidsicplinary team are needed in order to effectively troubleshoot, diagnose or optimize process dynamics, . In addition, the highly advanced systems in use to support plant operation may also require the involvement of specialiced expertise, often represented by an external supplier. Unfortunatly, collaboration between personnel from different disciplines, locations and organizational boundaries is today often hindered by the fact that the information needed to solve the problem at hand is hidden within numerous information silos. Knowledge workers in process operation still spend too much time searching for data in information silos or proprietary tools. Many companies also lack the organization and work processes to support multi-disciplinary collaboration, and therefore tend to execute work based on a relay race approach instead of an collaborative effort.

However, industrial companies are realizing that they need to improve they way they work in order to stay competitive in an increasingly volatile marked. The digitalization trend is sweeping across the industries and companies are taking actions to improve workforce effectiveness through the introduction of digital technologies. Many companies are introducing Bring-your-own-device (BYOD) policies and deploy solutions to enable their workers to work effectively wherever they are; at the office, on travel or working from home. Although industrial applications have been lagging behind the consumer and enterprise solutions, industry is now catching up in order to provide the same level of digital support to the industrial worker and the office worker; whether they are in the control room, outside in the plant, or working remotely. Information previsouly hidden within the control systems or proprietary tools are now increasingly made available through improved connectivity and integration across different systems and network layers. Web based applications are available to support consolidation of data from different systems and tools; making these easily accessible from one place. Easy access to data and a common work environment is the first step to enable effective collaboration to support process operation. Improvements in analytics and visualization techniques also help the workers to make sense of the increasing amount of data available.

Other technology trends are also supporting a new collaborative way of working. After many years of teething troubles, video conferencing technology has matured and is moving from being a nice-to-have technology to a neccessity. Several companies now have remote operation centers which support the local control rooms with contiuuosly open video links between the different locations. High quality video conferencing technology is also available from mobile devices or personal workstations, enabling operators to get instant access to remote expertise via video conferencing whenever they need it. In combination, the introduction of digital technology for easy accces to information, independent of location, and the proliferation of video conferencing to support remote collaboration, are blurring the boundaries between local and remote operation.

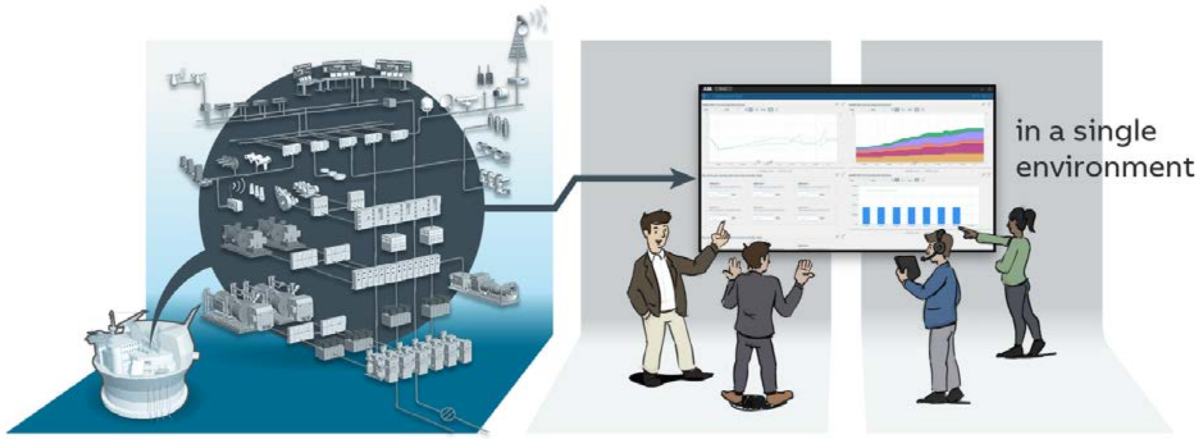

Figure 2 Collaboration across locations, disciplines and organisations

3 Insights about process operation

Modern automation systems can cover most aspects of normal operation and even handle many abnormal situations. Advanced control techniques such as model-predictive control (MPC) and State-based control (SBC)[5] allow to automate very complex tasks, such as the startup of a plant. Automatic control performs better than typical human operators. The operator is less and less involved in the inner control loops with direct contact to the process. The tasks shift more and more to supervisory control [6], where the operator manages and supervises a huge number of control modules. But being less involved in direct process control also means less possibilies to develop a feeling for the process by training on the job (a problem that was dramatically illustrated with the accident of flight AF447 [7]. The autopilot discovered inconsistent speed measurements from all three redundant speed measurements and switched into manual mode. The pilot didn’t have enough experience in flying at great heights and was overburdend with this sudden and unexpected transfer of responsibility. He went into climb mode which reduced the speed of the plane and finally led to the crash).

To be able to take over when automation fails, operators need higher qualifications and a deep understanding of the technical process, the automation system and the control modules. Simulator training is necessary to develop a feeling for the process. Modern operators should also be deeply involved in the optimization of process operations, because such an activity keeps them involved and helps to build up the required knowledge that allows them to take over in case of automation failure.

Another area where Industry 4.0 will have huge impact is industrial quality control [8]. Big Data techniques allow to distill historical process data into algorithms that can predict the quality of the currently ongoing production [9]. Upcoming problems can be detected early and countermeasures can be taken before the impact of the problem becomes significant. Previously it took an operator literally many years to accumulate a comparable experience.

Remote expertise should be brought in for all complex and difficult decisions. For example in the case of the Deepwater Horizon oil spill [10], the investigation report clearly states that one major contributing factor to the accident was the incorrect interpretation of available measurmements. Quite likely, advice from highly qualified remote experts would have avoided this accident.

The high complexity of modern plants requires deep expertise from many different domains (e.g. MPC, chemistry, electrical Drives, DCS). It is impossible for most plants to hire persons with sufficient knowledge in all these areas permanently. Modern collaborative environments make it possible to bring in remote expertise as needed.

4 Process Performance Optimization

Classical Key Performance Indicators (KPI) for process operations in areas such as Control Loop Performance, Alarm Management, Engergy Efficency and Overal Equipment Efficiency are described in detail in [11]. Managing those KPIs is not a classical operator task but is becoming more and more important to ensure good production performance. Different disciplines such as Operations, Maintenance and Analytics need to go hand in hand to achieve best results. Many of the tasks can either be performed by centralized internal service centers or can be outsourced to specialized external service providers.

Typical goals are increased throughput, efficiency, and uptime for the production plant [12]. This is done by a structured approach to revealing the sources of process variations and upsets and the current handling of these. By reducing process variations the operational flexibility, plant regularity, safety and integrity will be increased, while off-spec production, energy costs, environmental impact, operator stress, and equipment wear will be reduced.

For example, Dow Chemical has introduced a global analytics layer that turns the vast amounts of data into information and metrics anyone could use [13]. Experts from a centralized Analytical Technology Center can now support plants globally to determine manufacturing barriers, improve efficiencies and develop best practices. World class expertise, methods and tools have now become available.

5 The operator role and focus will change

As shown in previous sections, most simple parts of traditional operator work have been taken over by automation. Modern operators now have a very different profile. They supervise large numbers of control modules and must be able to quickly diagnose complex situations, collaborate with different support units and also coordinate field operators and maintenance personnel. They decide when it is time to bring in external expertise and manage the temporal integration of remote experts. To make use of their full potential, they need a work environment that really supports their work.

A challenge will be how to design the new more collaborative environments that will replace the traditional control rooms. Often those centers will no longer be physically close to the process, but they need to be much better integrated with remote service communities in the own company, service providers or suppliers. New collaboration centers can also be implemeted to work through different steps in modernization before the entire technology and organization is ready to utilize all benefits.

The involvement of experienced control room designers from early on is even more important in the design of next generation collaborative operations centers. They require a totally new approach and future integration thinking. As the traditional way of building control rooms turns obsolete, new best practices will have to be defined.

The new centers will contain less operators and the operator role will evolve from reactive to predictive problem solving and analytic operating. The new operator role requires higher qualification of staff and poses higher demands on the working environment. In a modern intelligent Collaboration Center, the working environment is the key to real control.

It will become more important to have motivated, stimulated and more alert operators with better education to deal with increasingly bigger parts of the production process. The space around the operator will be more connected to many other different functions such as IT/OT support, multifunctional support, technical & remote support, Asset Risk Management, Alarm, Safety Cyber & Security, Maintenance Management, that were previously often separated from the traditional way of running a control room. More interactive, frequent communication with different remote service people to jointly solve troubleshooting and optimization tasks will require a work environment to support this kind of work as well as if they were working in the same room. These new workflows, still rare today, but which will be the norm tomorrow, have completely new requirements concerning room layout, different working zones, screens, cameras, analytical tools and remote collaboration workspaces.

It is also a fact that working in 24/7 environment reduces the life expectancy of the employees. Already now there is ongoing research to understand how we can establish an individual health improvement micro environment that can be adapted to each individual operator. Figure 4 shows a typical integrated platform that is much more than an advanced motorized operator desk. This platform is a complete health improvement micro environment that can be adapted and even automated to change for each individual operators depending on individual needs. For example the distance between eyes and screens can automatically be adjusted with imperceptible slow speed to release muscle tension of the eyes, and the lighting can shift from warmer to colder light during different time of the day. These are just two examples of how technology can be used to support health and well-being of the operator. New technology and big data analytics makes it possible to create a data-driven “day by day” improvement program for operators. The new collaborative operations center will turn big analyzed data into actions and, thanks to Industry 4.0, yield a lot of benefits in becoming faster, safer, more competitive and of course more profitable.

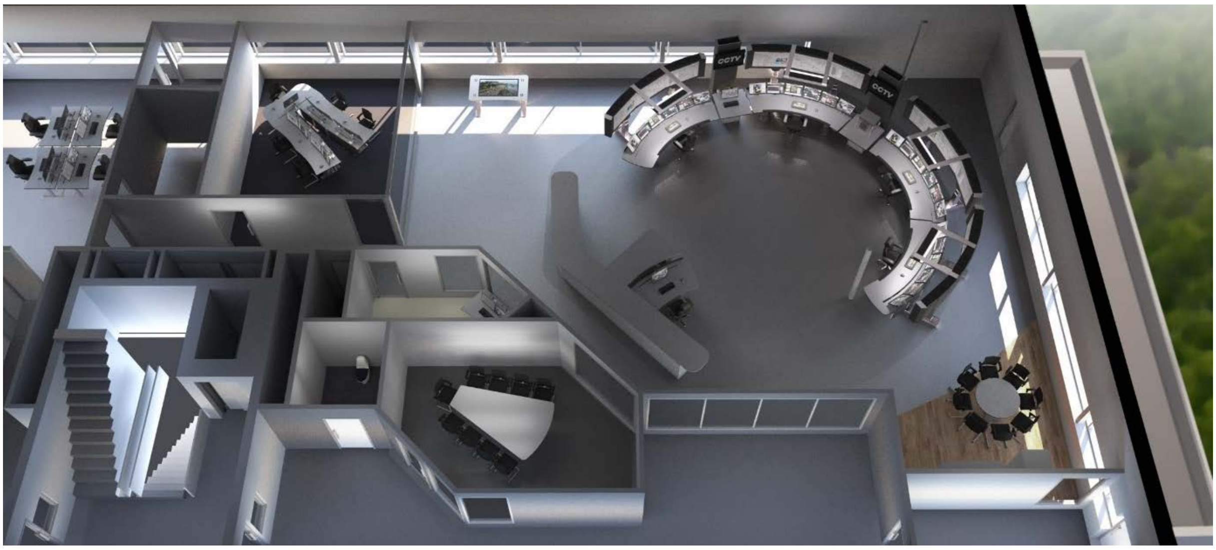

Figure 3 Newly designed collaborative operations center

Figure 3 shows an example of a newly designed collaborative operation center for an energy and environment company. 5 traditional control rooms with 12 operators will be replaced by a new collaborative operations center hosting 2 operators who will call in remote expertise on demand.

6 A new generation of operators

Generational shift will impact business markets and the industry sectors as the older generation (e.g. baby boomers) retires. One challenge will be to attract the next generation of operators, often referred to as the Generation Y, Gaming Generation or Multitasking Generation, into the control room working environment. An average gamer executes up to 300 actions per minute, while a non-gamer can perform maximum 100 actions per minute.

Personal ergonomics are becoming more and more important in order to improve health and well-being in the control room working environment. Human Factors involvement in the early stage of design layout is even more important in future control rooms or control centers considering the entrance of the next generation into the industrial field. We must seriously consider the needs, requirements, behaviors and values of the next generation of operators that need to be attracted to the industrial world.

The only way to encourage the next generation of operators to work in control rooms is a holistic approach to the control room working environment. Acoustic disturbances will play a key role when a host of operators have to share a common working space, communication devices, navigation keyboards, etc.

Improved illuminationis another area of concern because we know that interrupting individual circadian rhythms can have devastating consequences for shift operators. Air quality, heating, air conditioning and ventilation also matter in order to enhance human performance in the control room working environment. Dedicated Operator Fatigue Management minimizes the incluence of fatigue [14].

Identifying the needs and establishing the requirements of the next gaming and multitasking generation of operators can be achieved by using human-centric design. Technological development driven by the operators' needs will transform the working environment. Designing for people takes into consideration aspects of the psychosocial working environment such as gamification, collaboration, individual space, flexibility, learning, sustainability, social presence, emotional engagement, and creativity.

Figure 4 Modern Extended Operator Workplace

The knowledge gap is another problem that we will face when baby boomers leave the working field. One way of transferring knowledge from baby boomers to the gaming & multitasking generation is by introducing gamification as a motivation for learning, education and passing knowledge onto the next generation of operators.

Human-centered design that creates intelligent and individual working places is the way forward to meet these demands for the next generation of operators.

7 Conclusions & Outlook

In this article, we explained the shift away from traditional control rooms towards integrated collaborative control centers. Tomorrow's operators require a very different skill set with much more emphasis on cooperation, coordination, analytics and management. To be able to attract the best operators and offer them an environment which allows them to consistently bring high performance in 24/7 work settings, the integrated control centers should be designed by experts from early on. New digitalized infrastructures tear down information silos and make world-class remote expertise available. Optimizations previously not possible come into reach.

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