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Human Factor Principles in Remote Operation Centers

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Abstract

The uptake of operation support centers for monitoring and remotely controlling wellsite operations in real time is accelerating in the industry. This paper identifies and discusses the human factors involved with the successful design and operation of these centers.

The introduction of remote operation centers is having a significant impact on the physical and cognitive abilities of engineers working within the centers. Human Factors is a discipline that focuses on how people interact with tasks, machines, and the environment with the consideration that humans have limitations and capabilities. Human Factors must be considered in the planning, design and operation of any remote operation center to ensure productive and safe operation of the center. Locating operators remote from the tasks they are controlling or monitoring will affect not only the direct control and decision making processes, but will also affect their cognitive abilities and ongoing knowledge management and training.

In order to maximize the productivity of any system it is essential to design the workflow to take account of the new operational methods rather than trying to duplicate the existing workflows in a remote environment.

Introduction

The use of remote operation centers for monitoring and remotely controlling operations in real time is expanding within the industry. For instance, our internal organization operates 47 drilling centers and 16 wireline centers to help manage service quality. These centers monitor hundreds of operations with a population of dedicated surveillance engineers approaching two hundred people. Operations and workflows are vastly different for these surveillance engineers than their counterparts operating the tools in the field. This paper discusses lessons learned to make our people the most effective.

The concept of operation centers to support drilling is not new[1,2]. The value of remote operation centers has been well documented in the industry[3,4]. Reasons to introduce remote operation are to lower cost and increase the results for a hydrocarbon exploitation project. Specifically, remote operation centers are being introduced in order to improve the quality of operational decisions and reduce risks by:

- Managing age and experience profile of the workforce.
- Reduce risks associated with crew rotations and travel
- Ability to project skills and experience across a wider area more effectively
- Introduce and support new technology more efficiently
- Improve decision making

The design of remote operation centers and their workflows have a significant impact on the physical and cognitive abilities of engineers working in these centers. Data volume is increasing, while experience and field exposure are typically shortened. Engineers are being trained differently and using different tools. Without proper design of a complete system, supporting operations from remote locations can result in more responsibility in the hands of fewer, less competent engineers.

Exposure to safety risks is lowered by reducing staff levels in field locations. Furthermore, remote operations from a remote center reduces operational footprint at locations we work, and thereby reducing costs to operators. Decision making time is reduced. Staff retention and job satisfaction are also improved.

User-Centered Design Methodology

Human Factors and related disciplines encompass the body of knowledge about physical and cognitive abilities and limitations as well as other human characteristics that are relevant to job design. Ergonomic design is the application of this body of knowledge to the design of the workplace

User-Centered Design is the activity of fitting tasks to people. We design the facility around the operator, not force the operator to fit to the facility. Therefore the user should be placed at the center of the design, and then design the room around the interface between user and the products they use, the workspace they need and the overall environment that the facility resides in.

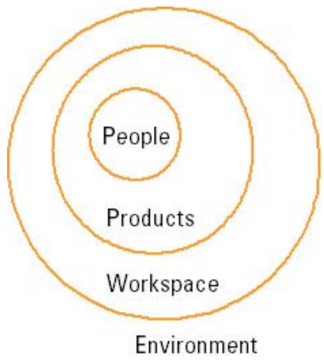

Figure 1 User-centered design

Putting user centered design principles into practice requires a methodology of focusing the design on the requirements of the user in conjunction with the technology available. We identified the following seven steps in the design methodology for a user-centered support center

1. Define workflows – Using a series of interviews and analysis the current workflows should be documented. Opportunities to improve the workflow should be identified at this stage. It is important to note the workflows that are *practiced*, rather than noting *idealized* workflows. The identified workflows must remain flexible during the design phase to ensure that we can adapt the technology and the workflows to make the most productive method of working.
2. Convert workflows to activities – Once the workflows are identified; they need to be converted to the actual activities undertaken by the operators. For example; part of the workflow may specify that the operator is required to run a data simulation. The actual *activity* for this task may require a meeting, a conference call or simply a quiet environment in which to concentrate. Variances usually take the form of activities in real time, off-line activities and support activities.
3. Define outline technology – Only once the activities are defined, we should start to identify and define potential technologies which support out workflows and activities.
4. Activities to layout – Convert activities into a draft layout by considering how these activities may work within a generic environment.
5. Prioritize layout to meet workflows – Each of the identified activities does not have equal importance within the operation center. By adding a weighting to these activities we can prioritize areas within the facility.
6. Format layout – The conceptual schematic should be formatted to fit into a realistic layout that can be applied to a physical space.
7. Apply design to workflows – The final stage is applying the design to the workflows identified in step 1 to ensure that the current design meets the identified aims.

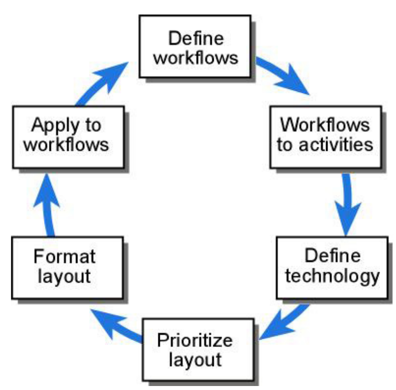

Figure 2 Design methodology

Technology selection

In order to maximize productivity in the operation center the workflows and the technology must be matched in order to support the user. Fixing technology too early will mean that the facility will be designed around the technology rather than around the user.

Technology can be split into two main categories

1. Core technology
   - key software applications (data viewers, data capture, reservoir modeling)
   - processing hardware
   - display and visualization
2. Secondary (or helper) technology
   - audio visual switching and control
   - communications
   - collaborative tools.

A common reason why operation facilities do not meet their full potential is in the failure to select secondary technologies correctly. Often seen as not core business, the selection of secondary technology is often left to 3rd party suppliers who may have in-depth product knowledge, but shallow knowledge on the processes or workflows to be implemented. Any technology selected should support the operator to make better decisions by

- allowing the operator easier access to the critical data
- allowing the operator easier access archived data
- allowing the operator to display and contrast data.
- allowing the operator to easily share data with others (either remote or co-located).

Facility design and its impact on the human interactions

Traditional control room design, with rows of desks facing towards a common screen (e.g.NASA control room), are not always suited to the design of a drilling monitoring room[5]. Although a large, shared, data screen can be useful, it is not always the best use of resources. This type of set up does not allow the degree of collaboration required. However where any room is dependant on real-time data (with an update frequency of 5mins or less) this layout can be applied provided it still allows for good communication between users. Where data is not in real time (sporadic data for example with update frequency of 1hr or more), or where there is a mix of real time and offline activities, the facility will be biased towards information sharing and collaboration. In this scenario the activities are usually biased more towards long term goals such as reservoir planning activities and require longer, more collaborative meetings, often with group input rather than individual decision making.

Main facility design issues

The following issues are the ones that have historically been the most challenging in operation center design

1. Space – Adequate space is required not only for the operators' workstations but also for circulation space, storage space, meeting areas etc.
2. 24 hour working – Most modern offices environments—the location for most operation centers—were not designed to support 24 hour working[6]. On an offshore installation, for example, amenities are available to the operators round the clock (meals, refreshments, showers, beds etc.) and contribute to the basic needs and general satisfaction of crews. Therefore, an office-based operation center must provide similar facilities for the safe and satisfactory support of 24x7 operations.
3. Noise – This is a critical issue within an operation center. There is a direct link between noise levels and operator concentration levels. Noise levels within an operation center should not exceed 50dB(A) (this should include all equipment fans, air conditioning and normal conversation levels). Special consideration should be given to requirements of high radio and telephone traffic in large facilities. It can be observed that increasing noise levels require operators to increase their own volume. Potential solutions to this include the use of headsets, which reduce the overall volume and limiting the volume output of any radios.
4. Lighting – Requirements for lighting are not as complex as they may seem. Light levels for a successful operations room should not differ significantly from those for a general office area. An average lux level of between 200 - 500lux[7] should be used. Current projection systems should be capable of displaying good contrast at this level. The only exception to this is in the positioning of lights. Lights should not be positioned directly adjacent to any projection screens as this will reduce contrast. The use of daylight is encouraged, with the exception of direct sunlight: Glare may result in eye strain, reading errors and reduced contrast on screens. Any windows should have means of controlling light entering the facility. Dark rooms are to be avoided as a good general lighting level provides better concentration and reduces errors.

5. Heat – This is another factor that could limit the operator's concentration levels. AC should be user controllable. Due to the 24/7 operations of most support centers, care should be taken in the design of the AC system. Many buildings have AC systems that shut down, or reduce cooling/heating outside normal office hours. It is usually necessary to provide a separate AC system for an operations support facility. Whenever possible, operators should be separated from computer processing hardware as this is a major heat (and noise) source.

Data visibility

Quality data entering the operation support facility is essential to the function of any control room. Good display of data is essential to maximize its value. Displaying too much data can have the same effect as displaying insufficient data. Size, type, and resolution of data display devices should be defined as part of the workflow analysis process (see User-Centered Design Methodology). In cases where an overview is required, it is a good idea to create custom "dashboard" applications to display data in a simplified format. The following are the common issues with data display devices

1. Resolution and physical size – Large screens do not always display more data than small ones. The available screen real estate is determined by screen resolution and not physical size. Size determines the viewing distance and the number of people who can view a particular image. Wherever possible there should be a standard screen resolution throughout the facility to facilitate easy data sharing across screens. Most LCD displays produce the clearest, sharpest image at their native resolution. This can cause issues as small PC monitors (19"-30") often have higher resolutions than the large format displays screens (40 – 72"+).
2. Video walls and processors – Modular display systems can get around resolution issues as video walls are built from modular systems, allowing extremely high resolution displays. However the success of systems is only limited by the control the operator has over them. Selection of any video wall, and its control system, must allow the operator to compare and contrast data in ways that allow making better decisions.
3. Viewing distances – The optimum seating distance from any screen depends on the size and type of the image, or data, being displayed. Both of these factors should be defined in the workflow analysis. For screen fonts the viewing distance would be defined by the angle of the image at the eye. This should not be less than 11mins of arc[8]

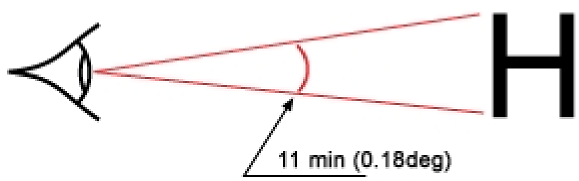

Figure 3 Visual acuity limits

Human Factor during Operations

Forgotten far end

Operation centers do not function in isolation. They are either paired with a remote field location, are the hub of a control/monitoring network or are part of an integrated chain or network. The functionality and productivity of any individual facility is dependant on links and the functionality of the far end location. It is essential considering the design of the far end when designing the main operation support center. Where software collaboration tools are used, the software—and the hardware it runs on—should be common. Screen resolution and graphics cards should be specified to be common to ensure data sharing is seamless. As with most communication, remote collaboration is only as strong as the weakest link.

Work/ life balance

Most operation centers should be capable of monitoring rigs around the clock. The rigorous monitoring actually results in a more predictable, planned work schedule. Engineers are now able to spend more time in the office and less time offshore. For example, work is now less dependent upon weather conditions: Where previously engineers could be stuck offshore waiting for a weather change to return home, they now visit rigs less frequently and consequently spend more time with family. This results in better staff retention, especially for medium to senior level staff.

Follow the sun

Working hour's regulations in some parts of the globe may result in three shifts of 8 hours each instead of the common two shifts of 12 hours. Handover requirements between shifts are one issue. Emerging is the "Follow the Sun" trend by proving operation support from three strategic global locations, for example Stavanger, Houston and Kuala Lumpur. In each location teams would work 8 hour shifts, providing support to global operations. This is particularly important for access to domain experts (senior geologists, reservoir engineers etc.).

Shift handovers

Shift handovers need to be planned carefully. The handover of responsibility from shift to shift is a potential cause of error. Remote monitoring and control introduces another link and therefore another potential source for error during handovers. Rig shift changes should be staggered with operations center handovers to ensure continuity and reduce the potential for communication errors. A standard operating procedure should be established for communication between operation center and rig site to ensure constant coverage.

Training, Learning and Experience

As data enters a remote operation center, the user is able to interpret this information and make conclusions and decisions based on their own direct field experience. As the data volume increases, so does the pressure on staff competence. Initially we will see a rise in business value of the facility as experienced operators are working in a data rich environment. If left unchecked we will see a reduction in experience level of new staff entering the operation center (due to the general decline in average seniority across the industry) and a reduction in the level of hands-on experience of existing staff.

Figure 4 Seniority decline

One of the functions of the support center staff is to maintain service quality levels with the decline in seniority of filed personnel. This level of support can only be maintained if we keep operation support staff experience and competence up to a defined level. Competence can decreases due to shorter exposure to wellsite operations. Also, the shortage of people drives staff sooner from the field to work from a central support center.

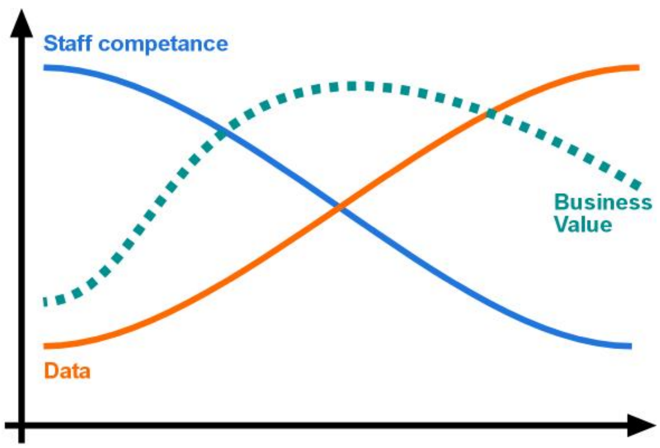

Figure 5 Business value and staff competence

Providing more data to less experienced operators will reduce the business value of the operation center and may lead to a reduction in service quality. If left unchecked, the ultimate result of automation is more responsibility in the hands of fewer, less competent, operators.

To prevent this from happening, the company must create and implement a plan to maintain the practical competence of the operation center staff. The plan should include the following:

- Plan for ongoing hands-on training and required learning
- Consider rotations in and out of the field
- Connect the center operator to the field site by all means possible to bolster the team
- Provide feedback where possible, including visual, tactile, audio feedback
- Allow decision making and judgment calls: Don't turn operators into alarm monitors

Conclusions and Recommendations

Remote operation lower cost and increase the results for a hydrocarbon exploitation project. In addition, remote operation centers were introduced to improve the quality of operational decisions and reduce risks. The following conclusions on the impact on human factors in operation center design are drawn:

1. Remote operations increase efficiency and ensure that critical expertise is available. More efficiency translates into lower cost, while safeguards in place have demonstrated that service quality is maintained. Access to expertise and efficiency increases the results for exploration and production hydrocarbon project.
2. Productivity in the operation center is maximized when workflows and technology are matched to support the user.
3. Remote operation centers should not be viewed in isolation, or viewed just from the perspective of the control room. It is essential in the design and implementation to consider the entire process including personnel at the wellsite.
4. Best practice is to analyze the workflows; not to replicate existing tasks or replicate the wellsite operational environment in the remote operation center.
5. Value is delivered when people work together using tools to facilitate their collaboration and increase their efficiency: Ensuring that people work together is established during the design of workflows.
6. The operation center design needs to account for how the center interfaces with the field, including not only relevant technologies.
7. The design of operation centers should be people and task centered, and not driven by technology
8. It is essential to strive for that the remote operation center and the far end will have common software, hardware, screen resolution, and even graphic cards. Secondary technology such as audio visual, switching and control, communications, and collaborative tools are key success factors. Although not core, the selection should be let to parties that understand the processes and workflows that are being implemented.
9. Round-the-clock operations require adjustments to most existing office facilities to provide needs and satisfaction of workers.
10. A well designed facility enable operators in a remote center to;
    - Concentrate more and for longer durations
    - Handle existing data more easily (display, compare, contrast and share)
    - Communicate more efficiently with others

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References

1. W. R. Isaacs, J.E. Bobo:"Design and Impact of a Real-time Data Center", paper SPE 13109, © SPE 1984
2. R.D. Foreman, "The Drilling Command and Control System", paper SPE 14387, © SPE 1985
3. E van Oort, R. Rosso, J. Cabello-Montero; "Evolution of Real-Time Operations Monitoring: From Concept to Global Implementation", paper SPE 97059 presented at the 2005 SPE Annual Technical Conference and Exhibition held in Dallas, Texas, U.S.A. 9-12 October 2005.
4. L. Ursem, J. Williams et al: "Real time Operations Centers; The people aspects of Drilling Decision Making", paper SPE/IADC 79893 presented at the SPE/IADC Drilling Conference held in Amsterdam, The Netherlands, 19-21 February 2003.
5. M. Wahlen, S. Sawaryn et al: "Improving Team Capability and Efficiency by Moving Traditional Rig-Site Service Onshore", paper SPE 78336, © SPE 2002
6. K. Lauche, S.J. Sawaryn and J.L. Thorogood: "Capability Development with Remote Drilling Operations", paper SPE 99774, © SPE 2006

(a) Lighting at work HS (G) 38 – UK HSE (b) CEN/TC169/WG2
7. Human Factors in Engineering and Design – Saunders, McCormick 1992
8. Schlumberger Oilfield Services 2007, unpublished data

Nomenclature

dB(A)	Decibel – Using “A” weighted scale.
Lux	A unit of measurement of the intensity of light. One lux is defined as an illumination of one lumen per square meter
AC	Air Conditioning