# HOLISTIC WORKSPACE:

# FUTURE CONTROL ROOM DESIGN

Tobias Schwarz[1], Flavius Kehr[2], Klaus Hermes[1], Harald Reiterer[3]

[1]*Siemens AG, Corporate Technology, Munich, {schwarz.tobias.ext, k.hermes}@siemens.com*
[2]*Department Psychology 8, University of Koblenz-Landau, kehr@uni-landau.de*
[3]*Human-Computer Interaction Group, University of Konstanz, harald.reiterer@uni-konstanz.de*

**ABSTRACT**

This paper presents an inter-domain context-of-use analysis which addresses the challenge posed by the constantly increasing complexity of the human-computer interface in the work environment of control room operators. The data gathered is taken as a basis to propose new ways of optimizing the operators' work environment as a "holistic workspace". New concepts are introduced which give equal consideration to the design levels of interaction, social communication, workflow support and physical surroundings.

KEYWORDS
Holistic Workspace, Control Room Design, Contextual Inquiries

## 1. INTRODUCTION

Control rooms, such as those found in tunnel control centers, air traffic control centers, power stations or police and fire service operations centers, are technical facilities for monitoring and controlling processes (Hollnagel & Woods 2005). Boring et al. 2005 point out that this is a context in which workplace design faces different challenges than those posed by a conventional office environment, since a majority of the complex processes involved are critical to safety. The operators' main task, common to all domains, is to reliably monitor and control complex, dynamic processes. The last few years have shown a trend toward growing complexity, due to an increase in the amount of information and the number of technical devices involved. In addition, in the face of increasing automation, operators are finding it more difficult to build a mental model of the processes they have to supervise. It is, however, vital to generate a mental model to be able to monitor the current system status, in particular for the purpose of determining changes in the dynamics of the process (Wickens & Holland 2000). The goal of the "Holistic Workspace" research project is therefore to devise a holistic work environment for operators, taking due account of new technologies and human-computer interaction design principles. This is to be achieved by developing a harmonized approach embracing both technical infrastructure (the user interface together with input, output and communication devices) and workflows on the one hand, and physical surroundings and social interaction on the other. The starting point for the research project was a context-of-use analysis, which was conducted in a total of six control rooms. This paper presents the main results of that analysis, and goes on to discuss concepts and ideas for a "holistic workspace" deriving from the findings made.

## 2. CONTEXTUAL INQUIRIES

A total of six control rooms were visited and analyzed by means of participative observation and semi-structured expert interviews; they included a fire service operational control center, two power station control rooms, a control room for an opencast mining site, an air traffic control center and a postal service automation control room. The context-of-use analyses comprised interviews with 13 control room staff members, among whom were both shift leaders and operators. In all, 12 different operator workplaces were identified, which were distinguished by their different areas of responsibility and their differing core tasks within the overall process. The smooth running of the process requires constant communication between the people involved. Sequence models (Beyer & Holtzblatt 1998) prepared during analysis show that (Figure 1), especially in abnormal operational situations, various channels of communication have to be used in parallel – for example, while a technician working on site can be contacted by radio, communication with the operations center requires a mobile or landline phone.

*Figure 1: Building sequence models (Beyer & Holtzblatt 1998) with the aid of photographs*

Added to this is communication between control room staff members, which takes place mostly face to face, but also indirectly using paper-based artifacts such as notes, memos or warning signs which express defined operational states. All this brings several channels of communication into play as media for passing on information. The wide variety of digital and analog communication options involves a corresponding number of devices – up to seven communication devices such as telephones, mobile phones and radio sets can be found at one workplace. Added to these are mice, keyboards, joysticks, screens etc., with the result that the average control room staff member has to operate and watch over anything up to 34 devices over the course of a working day. As part of the expert interviews, participants were introduced to future interaction devices and were asked to rate the potential usefulness of each technology for their own working context on a three-step scale (Yes, Maybe, No). 75% of interviewees said they would like *mobile devices* to supplement their current workplace devices, as many of the control room staff have have only limited opportunities – if any at all – to leave their workplace during a shift. *Multitouch systems* were seen as facilitating collaboration and being intuitive to operate, and were therefore regarded by 50% of interviewees as beneficial to their own working context. Most interviewees could also well imagine using *digital pen & paper technology*.

## 3. TOWARD A "HOLISTIC WORKSPACE"

The goal of this study was to explore the work environments of experts from domains of differing complexity. The findings made provide valuable insights toward the design of a new "holistic workspace", which considers the human being as a whole with the full repertoire of physical and social capabilities. As the results of the analysis reveal, the physical and social work environment plays an important role and has a dominant influence on cognitive processes throughout the workflow. A first approach can therefore consist in changing aspects of the physical environment such as the arrangement of workplaces. Future developments should, however, also provide greater support for collaborative workflows. Analysis has shown that collaboration within the control room and communication with on-site staff are essential components of everyday workflows, but that they are inadequately supported by current technologies, which neglect physical and social factors that are crucial to work activities. The devices and applications in use at present

make it difficult to respond flexibly in various different situations. Social interactions do, however, often find expression through indirect communication in the shape of real-world artifacts such as shift logbooks, shift rosters, checklists and notes. This kind of implicit communication is primarily important for overarching activities such as coordination and communication between operators, and is often inadequately supported. Information visualization and message management within software systems also do little to relieve the cognitive burden on operators – instead it is frequently the case that all incoming messages are displayed, so that ultimately it is the operator who has to take decisions on the importance and priority of individual messages. Furthermore, incoming messages cannot be called up consistently from a variety of locations, which makes it impossible to work away from the workplace. As a result, processes such as shift handovers may suffer disruptions. This is also seen as a problem area by control room staff members, who recognize that there is optimization potential in the visualization of information and the harmonization of devices. Future developments in the control room context should therefore put greater effort into devising harmonized, sustainable concepts tailored to the cognitive information processing skills of the operators, and also to their social and physical capabilities. Analysis has further shown that today's development efforts always treat the individual product, and never the human being, as the focal point when considering the composition of devices at the workplace. The operator is confronted with a hotchpotch of devices and has to cope with a large number of software products. Particularly in a critical situation demanding the ability to develop problem-solving strategies (Wittenberg 2000), the large number of different devices and software products might lead to cognitive overload, resulting in wrong decisions (Grams 1998).

# 4. DESIGNING THE „HOLISTIC WORKSPACE“

Findings in cognitive science confirm that there is a close connection between thought processes, perception, and physical and social actions (Dourish 2001). The implication of this for the design of interactive systems is that attention must be paid to human physical and cognitive abilities, and the context and social environment in which they are applied (Dourish 2001). Findings in cognitive psychology, multimodal interaction, and *tangible* and *social computing* are subsumed under a new paradigm termed *reality-based interaction* (Jacob et al. 2008). This paradigm proposes that human-computer interaction should be based on the real world, so as to utilize human characteristics and modes of behavior as acquired by experience and determined by evolution. The aim is to make specific use of new computer-based interaction and communication technologies to take pressure off people in their real-world workflows. One *single* enhancement in the closeness of interaction to reality goes only a very short way. The special challenge, and from the user's viewpoint the decisive benefit, lies in a meaningful interplay between tried and tested ways of doing things in the real world and their digital equivalents. Workspace design should not however be limited solely to human-computer *interaction*. Equal attention should be devoted to *communication* between operators, to their *workflows* and to the design of the *physical work environment*. Interaction concepts can only achieve a new level of quality in interaction if all these aspects (*interaction, communication, workflows* and *physical work environment*) are simultaneously and equally included in the interaction design. Figure 2 illustrates some initial ideas on how to implement the control room of the future. Multitouch technologies afford a form of communication that puts people on an equal footing, as they enable several users to interact (and work collaboratively) at the same time, with direct heed paid to social conventions. Direct manipulation also makes operation more natural. Furthermore, larger-scale visualization, for example on large wall-mounted screens, can support collaborative work during status review meetings and shift handovers. Wall-mounted screens may in addition be equipped with *ambient light technology* enabling them, say, to adopt a different background color scheme depending on the current status: in a critical situation, for instance, the screen might be framed in red. Going a step further, entire walls plus sound and lighting could be included in the interaction design. Meeting records and shift rosters can be written using digital pen & paper, making data available in both analog and digital form. This creates a practically seamless transition between the digital world and the physical workspace, since users can relate to their everyday experience regarding interaction with objects. From their workplaces, other team members can access meeting records or shift rosters anytime, print them, or look through the documents using a search function. All data is saved with a time stamp in a database; any changes made are documented and can be reconstructed anytime. In addition, data can be enriched with memos, so that any voice annotations needed can be recorded in context. The new

concept of a "holistic workspace" furthermore envisions workflow support by *mobile devices* (such as smartphones). By visualizing the most important messages, such devices enable operators to attend to their tasks responsibly and consistently from any of a variety of locations, thus allowing them to leave their own workplace.


*Figure 2: The idea of the "holistic workspace"*

Based on the findings made in these inter-domain analyses, the next step will be to build initial concepts realizing the vision of a "holistic workspace" for operators. In accordance with the initial ideas put forward in this paper, the aim is to enable seamless alternation between real-world and computer-based interaction and communication.

## REFERENCES


Beyer, H. and Holtzblatt, K., 1998. *Contextual design: defining customer-centered systems*. Morgan Kaufmann Publishers, San Francisco, USA.

Boring, R. L., Hugo, J., Richard, C. M., & Dudenhoeffer, D., 2005. The Role of Human-Computer Interaction in Next-Generation Control Rooms. *Proceedings of CHI 2005 - Special Interest Groups (SIGs)*. Portland, USA, pp. 2033-2034

Dourish, P., 2001. *Where The Action Is: The Foundations of Embodied Interaction*. MIT Press, Cambridge, USA.

Grams, T., 1998. Bedienfehler und ihre Ursachen. *Proceedings of Automatisierungstechnische Praxis atp 40 Part (3)*. Oldenbourg Verlag, Munich, Germany, pp. 53-56.

Hollnagel, E. and Woods, D., 2005. *Joint cognitive systems*. Foundations of Cognitive systems engineering. Taylor & Francis, Boca Raton, USA.

Jacob, R. J., Girouard, A., Hirshfield, L. M., Horn, M. S., Shaer, O., Solovey, E. T., & Zigelbaum, J., 2008. Reality-based interaction: a framework for post-WIMP interfaces. *Proceedings of Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems, CHI 2008*. New York, USA, pp. 201-210.

Wickens, C. D. and Holland, J. G., 2000. *Engineering psychology and human performance.* Prentice Hall, New Jersey, USA.

Wittenberg, C., 2000. *Virtuelle Prozessvisualisierung am Beispiel eines verfahrenstechnischen Prozesses*. VDI Verlag, Düsseldorf, Germany.