Practices of process control in digital control room: possibilities and threats

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ABSTRACT

This paper introduces an interview study that was carried out in Finland in four conventional power plants. The aim of the work was to gather user experiences on the effects of control room modernisations and digital control room technology on operator work.

Keywords

Control room modernisation, process control work

INTRODUCTION

In Finland the nuclear power plants (NPP) are currently undergoing control room modernisations. In the potentially high risk environment it is important to be fully aware of all the possible effects of a technology change. Especially the effects on operator work and thus potential safety implications need to be understood.

The study introduced in this paper is a part of a larger research project which aims at developing a method for the HSI (human-system interface) evaluation of nuclear power plant control rooms. The aim was to understand how process control work is carried out in digital control rooms, what are the potential threats for safe and productive work, and what are the possibilities offered by the new technology to increase the overall performance of the socio-technical system.

Control room technology has gone through extensive changes during the passed 5-10 years as the old technology consisting of wall and desk panels has been replaced with digital technology i.e. computer screens. Most important consequences of the digitalisation of control rooms have been listed by O'Hara (2003) and Pirus (2003): e.g. interaction with soft control method, increase in data availability to the operators, increase in data integration, hierarchical process representation instead of sequential, etc.

It is often claimed that a change from analogue control room technology to digital one has effects on the operator work. The changes that have been predicted are e.g. the following: small display space for information presentation introduces keyhole effect (Woods, 1995), soft control changes secondary tasks (Pirus, 2003; Woods, 1995), increased understanding of the automatic functions is required (O'Hara, 2003), and soft control requires conscious development of co-operation and communication practices (Hollan et al., 2000).

METHOD

The empirical research was conducted using a semi-structured interview method. Altogether 15 operators were interviewed in four power plants. The plants were selected based on the control room technology used, the time passed since the adoption of digital control rooms, and the power production process of the plant. The plants had all either carried out control room modernisation or had been fairly recently started up so that the control room technology was quite modern in all of them. None of the plants had had major changes in the control room during the passed 5 years which was thought to be important so that it would be possible to get a realistic view on operations after the first stumbling blocks had been passed. All the plants were conventional power plants since full modernisation projects have not yet been carried out in NPPs.

RESULTS

Understanding of the Automatic Functions

In general, the content of the work in modernised control rooms had changed from manual process operations to supervision of the automation. This is due to rise in the degree of automation. However the increased automation had not reduced the need of knowing how to perform operations manually. It was still seen as an inseparable part of professional skills, but nowadays the operators also have to master the functioning of the automation. Thus the demands on operator skills had increased and the sphere of responsibilities of an individual operator broadened.

Gaining Process Overview

The operators gained understanding of the process state by cycling through the displays, monitoring the most important process parameters, and by checking the alarm list. The operators claimed that they are able to find the right displays easily although occasionally it might take some time.

According to the operators' answers concerning process overview the so-called keyhole effect was not very significant in normal situations. Still, some of the operators admitted that in certain situations (e.g. start-ups) they are bound to leave some parts of the running plant outside monitoring. Also, some operators

preferred the old analogous wall panels as it is possible to get an overview of the process at a glance.

Operators appreciated the flexibility of the computer based tools (see also Vicente et al., 2001) because of the possibility to tailor the user interfaces by selecting which displays to use in different situations and where to place them. Although, it seemed that the number of monitors was not always sufficient for tailoring.

Maintaining Process Knowledge

Process knowledge is necessary for being able to conduct operations, for seeing if automation is working properly, and for developing an appropriate trust in automation. The operators emphasised the need to know the effects of the operations on the process and the constraints of the equipment to be able to operate safely and efficiently. In one of the power plants all control room operators worked regularly also on the field. Compared to others they had the best opportunity of keeping up process knowledge. In other power plants the operators had developed different ways of maintaining process knowledge. For example, the operators who could choose between using either analogue or digital controls sometimes intentionally carried out operations manually for the sake of remembering how the system works.

Changes in Co-operation and Roles

New ways of presenting information had made it possible to divide work in flexible ways. The operators working in fully digitalised control rooms were able to divide tasks as they wanted and they could assist the other operator due to the possibility of seeing the same displays. Also the field operators and the shift supervisor participated occasionally in operations but it was seen essential that the operators had the overall control of the process. Interestingly from the viewpoint of co-operation the operators claimed that nowadays it is easier than before to know exactly what the other operators are doing by calling the same displays they are using. Before, one could only assume roughly what the others were doing when seeing what panels they used.

Changes in Secondary Task

Changes in secondary task are hard to discover by interview method. The operators' opinions were contradictory. Some claimed that browsing through the displays and using a mouse was not problematic. They said digital interface allows you to concentrate on the primary task instead of the secondary. On the contrary some operators mentioned that they had had, and still had, difficulties with the new interface. They said that the process seemed more tangible when using analogue devices.

Learning the New System

The length of the learning time varied from a couple of months to one and half years. Putting the operators too early in charge of the controlling of the plant may lead to stress due to lack of self-confidence and fear of mistakes. Trust in own skills is gained in a couple of years, although one operator claimed that it takes as much as five years to learn how to operate and still after that one doesn't know every detail. Acquiring and maintaining knowledge of rare events seemed to be a problem for all operators. Many operators had the habit of revising procedures. For example simulator training was seen as a new possibility for rehearsing complex situations.

The operators are bound to rely on automation because using manual control continuously is not an effective way of working. However, it takes time before an operator learns to trust himself as a user of the system. Trust in own skills seems to have an influence on the level of trust in automation (see also Lee & See, 2004).

CONCLUSIONS

We conclude that modernisation of control room technology poses several challenges to safe and effective process control. When the technology is changed the operators' tasks and responsibilities change also. This needs to be taken into account when training programs are developed.

Operators' ability to create appropriate trust in their tools relates to their trust in their own skills and knowledge about the process. Taking this into account in HSI evaluation means that the training process should be included in total integrated evaluation.

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