PAPER II

Systems Usability Concerns in Hybrid Control Rooms

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SYSTEMS USABILITY CONCERNS IN HYBRID CONTROL ROOMS

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ABSTRACT

This paper presents findings from two large scale simulator test series which were carried out in the Finnish NPPs. Altogether 18 professional operating crews took part in the experiments and each of them conducted three scenarios at the training simulator of the respective plant. The studies provide evidence on how well-trained operating crews actually manage accident and incident situations in a hybrid control room. The tests were organized in order to have a solid reference in the possible future validation efforts regarding the human factors in the modernization of automation and control room systems. The systems usability (SU) evaluation framework has been developed to understand the role of tools in complex activity. In this paper, we describe the test results of these reference tests for the two plants: both, separately and by comparing the findings of the two cases using the SU framework.

Key Words: hybrid control room, evaluation, human factors, systems usability

1 INTRODUCTION

Digital user interface technology made its way to the main control rooms (MCR) of nuclear power plants (NPP) several decades ago. For instance, the process monitoring systems which analyze and present process data to be used by control room operators have been based on digital technology for a long time. Lately, control room upgrades have increased the significance of digital technology by introducing applications that exploit digital tools also in the interaction between the operator and the process. At the same time conventional solutions have also partly been maintained in the control rooms. Thus, the MCRs of both Finnish NPPs constitute now *a hybrid control room concept*.

A hybrid control room is a control room which simultaneously contains analogical and digital technologies. The hybridity can take many different forms; it is up to the modernization philosophy of the respective plants which systems or control room functions have been digitalized and which have remained in the original form. The primary motivation for the studies reported in this paper was originally the fact that not so much comprehensive systematically gathered data existed about the operating activity in a hybrid control room. On one hand there was evidence that operators are able, in their daily work, to cope with the hybridity of the control. This consideration is based simply on the fact that no major incidents had been reported to have been caused by the hybridity in the control room. On the other hand it can be hypothesized that the more hybridity is introduced in the form of new systems exploiting different generations of technology, the more confusing the overall situation will become from the operating point of view. Some anecdotal evidence from operators exists to suggest that operating so many different kinds of systems takes up too large portion of the cognitive resources. Also it had been thought that implementing evolutionary upgrades in the control room would only have an effect on the secondary tasks of the operators and thus the change from an operating point of view could be interpreted as minor. Secondary tasks comprise of user interface manipulations such as navigation. The scientific motivation for the studies presented here was to gain better understanding how the hybridity of the tools (the control room as an operating tool) has an effect on the operating practices. The practical motivation was to gather baseline data concerning operator activity in order to be used as a reference in later validation tests. Yet, another aim was a development of a comprehensive control room evaluation method which would highlight the role of tools in operating activity. In this paper we present two baseline evaluation studies which were conducted in the Finnish NPPs for the above mentioned purposes.

2 BACKGROUND

Acquiring reliable and valid information on the usability of control rooms in general and on hybrid ones in particular, is challenging due to at least two reasons. Firstly, operators tend to have divergent opinions on the usability of specific interface solutions [1]. For instance, some operators consider the monitoring and controlling of the processes to be easier in a digitalized control room as there the operator is able to perform all operations at the same display. However, others think that the fact of not being able to find directly some specific information from some specific display, opposite to the way information is found in the conventional control room, complicates operator's work [1]. Both opinions are well grounded, based on experience and feeling of control. Consequently, it can be demanding to find an appropriate solution as during designing, it is advisable to take into account conceptions of operators, even if they can be opposite to each other.

Secondly, the very way information is expressed in the user interface is unique in each control room. Each control room is tailored and for safety reasons, not very detailed information is even allowed to publish. Furthermore, even if the conventional hard-wired control room may force the existence of some general features shared in practically all control rooms, digitalization brings along the possibility of designing very different solutions, resulting in even more unique control rooms. Thus, it is hard to acquire or develop information that would be valid for control rooms in general. This is also reflected in the scientific discussion. For instance, it can be maintained both that there is easily too much data available in a digitalized control room which makes it difficult to find the relevant information [2, 3] but also that digitalized user interfaces diminish the mental load resulting from searching for information[4] - depending on the user-interface solutions in the control room.

Some general findings have been, however, identified. Examples of information or some kind of principles or facts on a general level seem to be that digitalized solutions offer more possibilities to edit the ways information is expressed [5]; that changes in user interfaces affect work practices of the operators [2]; that efficient [6-9] or perhaps even standardized [10, 11] communication improves performance; and that operators move less in a digitalized control room [5, 12, 13]. The variability in control rooms, or simulator control rooms, presumably slightly diminishes when knowledge of the most usual drawbacks has reached all stakeholders and lessons from poor design solutions are learned by designers , and when the most urgent or easily-realizable improvements on the new solutions are made and the working practices are settled. To reach the most positive end result, i.e., efficient and usable control rooms in the nuclear domain, information should be delivered in such a general level that it is valid to as large number of control rooms as possible. This paper aims at delivering this kind of general knowledge about operating activity in a hybrid control room.

3 THE THEORETICAL APPROACH AND THE METHODS IN THE STUDIES

This paper does not provide full theoretical justification for the methods applied in the studies. The aim is only to briefly describe the SU evaluation framework which provides comprehensiveness in the assessment and the kinds of methods used in the studies.[1]

3.1 Systems Usability Evaluation Framework

The SU approach [14] assumes that a tool in an activity has three separate but intertwined functions: instrumental, psychological, and communicative. *The instrumental function* refers to the tool's ability to have an effect on the environment for which it has been designed e.g. a hammer's ability to make the nails penetrate into a surface or a control systems user interface's ability to allow the user to manipulate process components. *The psychological function* refers to the effect that the tool has on the user. In order to be able to use the tool the user creates mental models and schemas about the tool as such. Even further, in the psychological function the tool shapes the user's understanding about the controlled process and the physical phenomena taking place in the process. Thus, the tool affects the user's conceptualization of both the tool itself and the controlled environment. *The communicative function* refers to the effect that the tool has on the community of the users. It means that by using the joint tool the community adopts and shares vocabulary, knowledge and even values concerning the work. Most importantly, the communicative function stresses how meanings are conveyed by the tool in the community.

In evaluating SU (i.e. considering the fulfillment of the three above mentioned functions) the usage activity must be approached from multiple perspectives. The first perspective is concerned with the outcome of the performance. With outcome we mean concrete measurable results of activity which can be observed by an external observer. This perspective answers to the question of what happened during the course of activity. In a safety-critical context the outcome alone is not sufficient to describe the activity, thus the second perspective is concerned with the way of acting. The way of acting answers to the question of how, concerning the mechanisms producing the outcome of activity. The reason why way of acting is so important is the fact that since the CR operators are experts in their field, all the participating crews tend to reach the acceptable level of performance outcome at least in operational situations that are well trained. This means that more subtle means of analyzing the activity are needed to understand the internal quality of activity. Way of acting analyses the activity from the point of view of practice and its orientation to the core demands of the domain. The third perspective to activity is the user experience. This perspective is concerned with how the operating crews themselves view the technology in testing. We are interested in the qualities of experience and awareness that is accumulated in action, because it reveals inherent features of action that cannot be reached by observation from outside.

3.2 Data Collection Methods Utilized in the Studies

Similar data collection methods were utilized in both studies to be described in the following sections. Basically both studies were usage experiment simulator studies conducted within the training program of the operating crews of the respective plants.

3.2.1 Orientation interview

In the beginning of each experiment session the whole participating crew was interviewed in an orientation interview. These interviews were conducted individually for each operator. The orientation interview is a fairly short interview concerning the operator's personal epistemic attitude towards work and the controlled process [see more in 15]. Orientation interviews lasted from five to approximately 25 minutes and contained six defining questions concerning NPP process operator work. All the interviews were audio recorded, transcribed and analyzed qualitatively. The scale of orientations was: interpretive,

[1] A more detailed theoretical elaboration of the method is under preparation [18].

confirmative, and reactive [see more in 16]. An interpretive orientation emphasizes interpretation of the general rules of the domain always in the light of the particular situation at hand. Confirmative orientation emphasizes rules and norms. Reactive orientation reflects passivity towards work. The orientation interview results were utilized in analyzing the communicative function of the tool.

3.2.2 Observed process control activity in simulated accident and incident scenarios

The operating activity during simulated scenarios was video recorded with overview cameras and head mounted cameras. This data was later scored and analyzed both qualitatively and quantitatively. The observation data was utilized in order to construct a dynamic account of a crew's operating activity over time. The observation data was used in understanding all three functions of a tool.

3.2.3 Expert evaluation of crew performance

One of the simulator trainers acted as an expert performance evaluator in both plants. The expert had a pre-defined judgment scale which was defined separately for each scenario. For all the scenarios the scale contained the same themes: Detection, Diagnosis, Utilizing procedures, Stabilizing, and Co-operation. Each theme had several scenario relevant sub-measures. The expert observed the process control activity and simultaneously fulfilled the rating scale online. All the data were treated quantitatively and utilized in the analysis of instrumental function of the tool.

3.2.4 Task load assessment

Each operator's task load was measured utilizing the NASA TLX [17] measurement procedure after each separate simulator run. Task load data was utilized in the analysis of psychological function of the tool.

3.2.5 Process tracing interview

In order to gather the operating crew's conception about the simulated process control, a process tracing interview was conducted after each separate simulator run. In plant A the process tracing was conducted as a group interview for the whole operating crew and in plant B the procedure was conducted individually for each operator. This change in research procedure was a result from lessons learnt in plant A where the situation was such that typically one member of the crew took a leading role in answering the questions. In the process tracing interview the whole simulator run was reconstructed by asking the operators event by event what had happened in the run, what was the significance of each event, what control room features they had utilized in taking care of the event, and how they considered the adequacy of that specific control room feature. All the process tracing interviews were both audio and video recorded. The audio files were transcribed and the data treated qualitatively. The data was utilized in the analysis of psychological and communicative functions of the tool.

3.2.6 Systems usability questionnaire

In the end of each experiment session the operators individually filled in a systems usability questionnaire. The questionnaire contains 49 positive statements regarding the control room. The statements have been constructed with the aid of systems usability approach i.e. to consider all three functions of the tool. This means that there were separate statement sets for each instrumental, psychological, and communicative function. All the statements were formulated so that they posed a positive assessment of the control room and the operators were instructed to score each statement on a four point scale ranging from completely agree to completely disagree. The basic assumption behind the statements was that generally quite positive result should be obtained as the evaluation was conducted on a control room which is in daily use at both plants. All the data was treated statistically and utilized in the analysis of all three tool functions.

4 THE STUDY IN PLANT A

4.1 The Specifics of Plant A

Plant A is a two-unit VVER plant originating from the late 1970's and producing currently close to 500MW electrical power in each unit. The concept of operation is such that in a main control room (MCR) (one per unit) a standard operating crew consisting of three operators (turbine, reactor, and supervisor) operates the plant in normal conditions. In case of abnormal conditions a safety engineer joins the normal crew. The MCR is a hybrid composition of digital and analogue user interfaces. Process monitoring system constitutes perhaps the most important view to the process and is based on digital information presentation. All operations, except maneuvering of control rods, are conducted via original hard wired panels and operating desks. The emergency operating procedures (EOPs) are utilized in paper format and are in flow chart format. The EOPs had recently been renewed from event based at the time of the study. The control room and more widely the control concept is a product of extensive in-house development effort within the company. During the study the modernization (digitalization) of the MCR had been started.

The specific research questions concerning plant A was to formulate a performance based reference which could be utilized in the validation of new control room design. The plant had extensive plans on modernizing the control room in the near future. An additional research question was related to the usage of the recently renewed EOPs.

4.2 The Scenarios

Three different scenarios were developed in the training organization of plant A. The scenarios at plant A were: 1. Loss of coolant accident, 2. Primary secondary leak, 3. Electrical bus bar failure. Scenarios 1 and 2 are so-called design basis accidents, which means that specific emergency operating procedures cover the necessary process interventions which operators are required to carry out. An additional plant protection signal failure was added in the scenario 1 to increase complexity. In scenario 3 it is not evident which operating procedure would best suit the situation and the event is not part of the normal training program of the crews.

The scenarios were analyzed carefully by the researchers and the simulator trainer who acted as an expert evaluator of performance in order to formulate the evaluation bases for performance evaluation and the evaluation of operating practices.

4.3 The Participants

All twelve operating crews of the plant participated in the study which means that altogether 46 operators acted as users in the experiment. In general an operating crew consists of three licensed operators, but in many of the crews there were trainees who also took part in the simulator exercises. The operating experience of the operators in plant A varied from 1 to 32 years of experience. There were 18 participants in the experience group 1 - 9 years, 13 participants in the experience group 10 - 19 years, and 13 participants in the experience group over 19 years.

4.4 The Results Concerning Plant A

The data analysis was conducted by the researchers and reported back to the operating unit as part of operators' yearly class room training. In this paper we concentrate mainly on those results showing difficulties in the operating practices and which seem to be caused by the hybridity of the control room solution.

The performance of the crews (expert rating) was overall good (mean values between 3 and 4 out of 5), and the performance differences between crews were not statistically significant. Based on the results of the expert performance rating it can be said that the performance outcome in each scenario was on a satisfactory level. In this conclusion the measure of satisfactory level performance is that of not endangering safety e.g. completing the requirements expressed in the emergency operating procedures.

In the two accident situations (scenarios 1 and 2) the crews' task loads were overall lower than in the electric bus bar system failure (Fig. 1). For the accidents emergency operating procedures exists but for the electric bus bar failure there is no one specific procedure. The electric bus bar failure scenario as such was not as severe as the accident situations but the task loads were still higher. The scenario's effect on each task load factor except frustration was statistically significant ($p<0,05$) or very significant ($p<0,001$).

In the analysis of operating practices there were some differences between the crews. Differences existed in the amounts of communication and movement around the control room, especially for the shift supervisor. Also there were differences in the extent of using and communicating of process information for decision making. One remarkable difference between the crews in operating practice was found. In scenario 1 (loss of coolant, LOCA) there was a small additional failure. One of the plant protection signals (containment isolation) did not function correctly. The checking of the protection signals is not in the beginning of the LOCA procedure, but nevertheless, the operators, if they are aware of the endangered safety functions, should be aware of the status of the containment isolation. Only one crew managed to notice this failure and take the measure to correct the situation before it was mentioned in procedure. This was considered to be variation in the operating practice.

There were qualitative differences in the orientations of the operators. When all the answers of all the operators were coded 29% reflected an interpretive orientation, 48% a confirmative orientation, and 23% a reactive orientation. The result is not poor as such, but among professional operators with quite long experience in process control work we might expect the interpretive orientation to be more common. As the confirmative orientation is by far the dominant it can be concluded that operators tend to maintain an attitude according to which process control work is confirmatory activity in which it is enough to follow and obey the rules and procedures.

According to the responses of the systems usability questionnaire, the operators experienced the usability and functionality to be more positive than negative. 31% of the positive statements were completely agreed with, 56% somewhat agreed with (Fig. 2). The most negative experiences concerned complexity caused to the operators' work by the user interface, error possibilities and especially recovery from errors in the user interface, difficulty to learn to use the systems, support for finding right operative solution in an unclear situation, help of the procedure in understanding process situation, support for personal styles, and support for adaptive activity.

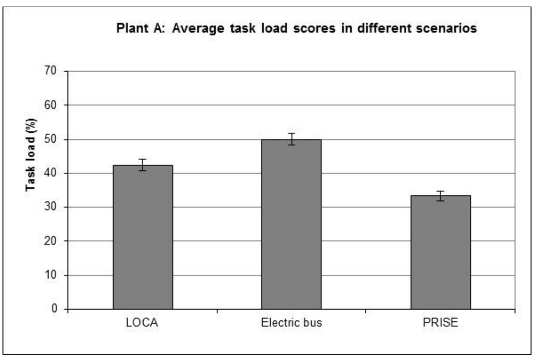

Figure 1. Task load scores in different scenarios. LOCA refers to loss of coolant accident and PRISE to primary-secondary leak, both of which are accidents. Electrical bus bar failure scenario resulted in higher task load values than the other two ($p<0.05$).

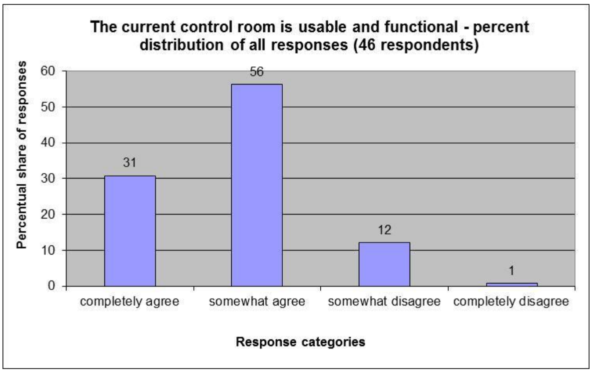

Figure 2. Summary of all answers in the systems usability questionnaire (Plant A).

5 THE STUDY IN PLANT B

5.1 The Specifics of Plant B

Plant B is a two-unit BWR plant originating from the turn of 1980s producing close to 1700MW electrical power. The concept of operation is similar to the plant A as there are three main operators in a normal crew (turbine operator, reactor operator, and shift supervisor). One significant difference is that in addition to the three MCR operators one extra person is almost always present in the control room: a supervisor for the field operators. This supervisor often even has a license of a turbine operator and depending on the level of expertise s/he might take part in the turbine operations or the overall problem solving conducted by the crew.

The MCRs of plant B are truly hybrid in nature. The turbine side operating interface has been digitalized some years ago and thus all turbine operations (excluding some manual back-up) are conducted via soft control methods. At the same time all primary side operations are conducted in traditional user interface. In plant B there is also a process monitoring system based on digital information presentation which is used by both turbine and reactor operators. In the turbine side modernized user interface there are embedded many kinds of additional information for the operator e.g. procedures and information concerning automation (logic diagrams).

The specific questions of plant B were to gather operating experience of the current control room solution as there had not been comprehensive performance based studies conducted since the non-safety related turbine side user interface modernization. At the same time a reference data might be needed some time in the future if further control room modernizations would at some point be needed.

5.2 The Scenarios

In plant B the scenarios were developed with the help of the simulator training organization and the specific questions mentioned above in mind. The scenarios were decided to be smaller-scale incidents which, if not responded adequately by the operating crew, would lead to automatic scram and of course to production losses. The scenarios were: 1. Failure in decay heat removal system; 2. An ejector failure; and 3. An automation failure in a pre-heater line. Scenarios 2 and 3 were combined so that they were represented as one continuous flow of events. In comparison to plant A the plant B was not interested in the utilization of EOPs and thus specific accident scenarios were not chosen.

5.3 The Participants

In plant B six operating crews participated in the study. Altogether there were 24 participants and the operating experience varied from 0 to 31 years. 12 operators had operating experience of 0 – 9 years, 3 operators had operating experience of 10 – 19 years, and 9 operators had operating experience exceeding 19 years.

5.4 The Results Concerning Plant B

In plant B the overall performance ratings of the expert varied between 2 and 5, but the average ratings were quite good varying between 3.5 and 3.9 (out of five). The lowest ratings were given for detection and use of procedures.

In plant B the scenario 3 was by far the most difficult for the operators to handle. It involved a failure in the automation system which was very difficult for the operators to discriminate from a process failure. The new digital interface would have given the operators an opportunity to detect that it was indeed an automation failure. However, only one crew was able to make this detection and thus avoid an unnecessary reactor scram. In the further analysis of the operating practice of this one crew it was detected that the amount of communication in this crew was higher than in the other crews. The same difference was reflected in the time that the crew spent physically together, communicating and interpreting information provided in the user interfaces. This finding suggests that this one crew had developed superior collaboration practices.

The effect of the user interface on operating practice was evident in the amount of movements of the operators. The turbine operators who use the digitalized user interface moved less than other operators. Another notable result of the analysis of movements was that of total time of movement of the shift supervisor. The shift supervisor was away from his own station more than either of the two other operators in scenarios 2 and 3 which both involved more the turbine side (digital user interface) of the process.

There were quite large differences in the task loads when compared between the different operator roles (Fig. 3). The turbine operators reported the highest loads in all subscales. The effect of the operator role was statistically significant for subscale frustration ($p<0,01$): The turbine operators were significantly more frustrated than reactor operators and shift supervisors. In addition the effect of the operator role was statistically nearly significant concerning physical demand ($0,1 < p < 0,05$): The turbine operators considered the operating conditions physically more demanding than reactor operators. This is an interesting finding considering that the turbine operators were the ones utilising the modernised user interface.

In the orientation of the operators towards the process there were also differences. When all the answers were coded and the results calculated, 23% of answers reflected an interpretive orientation, 58% a confirmative orientation, and 19% reactive orientation. The confirmative orientation is by far the dominant which reflects the prevailing attitude of understanding process control work as confirmatory activity in which it is enough to follow and obey the rules and procedures.

In answering the usability questionnaire the operators of plant B perceived the current control room quite usable (Fig 4). Concerning the usability and functionality 35% totally agreed with the positive statements, 52% somewhat agreed, 12% somewhat disagreed and 1% totally disagreed. Thus majority of the conceptions lay on the positive side. Also the answers of the turbine operators, who have the modernized user interface in use contained more completely agree answers than those of reactor operators and shift supervisors (40% vs. 27% and 30%).

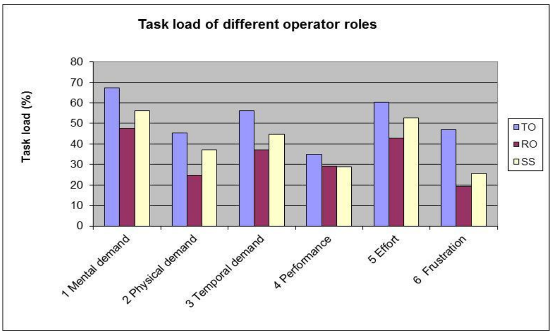

Figure 3. Task load of different operator roles, all scenarios combined. TO = turbine operator, RO = reactor operator, SS = Shift supervisor. The turbine operators have the highest task loads.

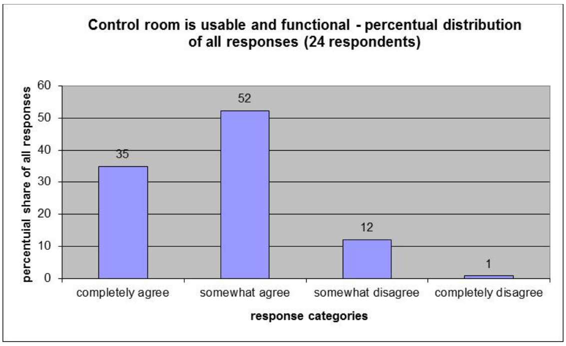

Figure 4. Summary of questionnaire answers in plant B.

In the open comments and process tracing interviews some critique on the user interface was nevertheless presented. The main problem was that the needed information is spread all around the control room. Also, the information monitor might be far from the operating interface. Also alarm system presents itself as problematic to the operators. Alarms are too many, and the information value is not high enough especially in the situations when it would be needed.

6 THE RESULTS COMBINED: SYSTEMS USABILITY

6.1 The Instrumental Function

In the instrumental function both of the evaluated control rooms worked quite well. This means that the operating crews were able to effectively carry out the control operations considered necessary in the simulated accident and incident situations. This issue is featured in relatively good operator performance results obtained in both plants from expert judgment. As in plant B there were some low performance scores obtained (detection, use of procedures) this may reflect the hybridity as different operators utilized different type tools. Generally the results from systems usability questionnaire were also on quite good level. When the statements concerning instrumental function were analyzed separately for both plants it was found out that the percentage distribution of answers was such that in plant A 35% of the statements were responded with completely agree and in plant B 30%. Some problematic issues concerning instrumental function were however identified. The most problematic issues concerning instrumental function were problems with feedback in a digital touch screen solution (in plant A). The operators stated that it is not always clear whether a command has been implemented. Another problematic issue was the possibility of errors in using especially the digital interface. The recovery from errors was in addition experienced problematic. Also the operators claimed that the systems in the control room do not help in focusing on the relevant phenomena when support in that is needed. These issues were common in both plants, and as both constitute a hybrid solution it may be one of the causes of the problems.

6.2 The Psychological Function

Although the psychological function was also supported relatively well it was the most problematic of the three general tool functions. In the questionnaire data only 25% in plant A and 28% in plant B completely agreed with the positive statements concerning psychological function. The learnability of the control room systems was considered in both plants not to be on an optimal level. Even though the control room is a complex system and thus cannot be effortlessly learnt to use, the operators made statements that in fact it is confusing to have different information presentation principles and notations within the systems of the same control room. The learnability is affected by hybridity as it induces more learning challenges in the form of multiple different systems utilizing different interfaces and operating logics.

In plant B where there were more digital user interfaces in use, the understanding of the automation information provided in the interface was not completely in an optimal level. Only one crew was able to solve an automation related problem in scenario 3 and was thus able to avoid production loss related to an automatic scram. In the analysis it was found out that the problem was related to the psychological function because the other crews' abilities to utilize the system were not on the same level with the system capabilities. This is related to hybridity as it might polarize the skill levels between the different operating crews. In plant A there were differences on micro-level in the crews' operating practices in proceduralised scenarios. We considered this also as a problem in the psychological function of the tool: Not all crews had been able to create higher levels of way of acting which would be manifested in the crews mitigating actions concerning the core safety functions of the plant.

A positive issue concerning psychological function was the new state-based EOPs in plant A. They truly seemed to lessen the task load of the users.

6.3 The Communicative Function

Overall, the communicative function lies somewhere between the psychological and the instrumental in terms of successfulness. In plant A 29% of the questionnaire answers were completely agreed upon and in plant B 44%. Most problematic communicative features according to the questionnaire data concerned the interpretation of the utilized sounds in the control room, operator support in unclear situations, and EOPs ability to find new solutions. Also the fact that operator orientations lay mostly in the confirmatory category was considered to be a problem of the communicative features of the control room. The tool should support more firmly an operating attitude which sees process control work as a higher level functioning the aim of which is to ensure nuclear safety. The differences in the collaboration practices (movements, communication, time spent together) show weakness in the communicative function of the tool: Not all crews are able to collaborate effectively and efficiently in the control room.

7 CONCLUSIONS CONCERNING HYBRIDITY

Although both studied MCRs constitute a unique case, some general conclusions can be drawn concerning hybrid control rooms in general. After a careful analysis we considered hybridity not to be problematic from the operating point of view per se (operators seem to cope well), but it is also evident that some of the problems in the user interface and the human performance may be caused by the hybridity of the control room.

The problems in instrumental level might be caused by hybridity. The detection problems in plant B and problems in use of procedures are areas in operator work which are heavily affected by the tool that is used. Also in plant B it was witnessed that turbine operators utilizing the modernized interface were more satisfied with the tool. This is a hybridity related concern as it might cause polarization in operating practices.

It was evident in both plants that the psychological function of the control room was not on an optimal level. This is an indication that hybridity causes confusion in the operating work. This means that more careful attention should be paid both to the consistency throughout the different systems (in overall operation logic) and to the training processes. We claim that in a well-functioning psychological tool there would not be inconsistencies in the operating practices between the crews because the functionalities would be such that they could be exploited by all the crews to the same extent. In the current solutions there were tendencies in the operation practices to break into two opposing groups. This is a weakness on the overall level because in the long run it means variation in the performance outcome also.

The communicative function is reflected in the ways operating crews collaborate in the control room and also in the ways the control room systems manage to convey meaningful information for operations. Based on the findings in the reported usage experiments the communicative functions of both studied control rooms could be improved. The improvement needs were evident in the results of the orientation interview results of both plants. The dominant orientation was confirmative which reflects an attitude towards work according to which process control work is confirmatory in nature. This means that the benefit of hybridity, the variety of information presentation formats and operating interfaces has not been exploited by the operators. Bu rather, it works against the development of the interpretative orientations.

In this paper we have presented two simulator studies which have been conducted in Finnish NPPs. The results show that hybridity as such is not extremely problematic but it poses new demands on processes of training and learning. These problems may not become evident in the performance outcome of operating activity but rather are visible on the level of operating practices. Also consistency concerning different features of the control room becomes easily compromised within a hybrid control room. As a solution for these problems we propose more continuous monitoring (evaluations) of the prevailing operating practices and the practice point of view to be exploited also in the design of new control room features.

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