HUMAN FACTORS IN THE DESIGN OF CONTROL-ROOMS FOR ESS

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Abstract

Norway contributes in kind to the building of European Spallation Source ERIC (ESS). Part of this work concerns the human factors aspects of the control-rooms for the operators of the machine. IFE is applying international standards on human factors (e.g., ISO 11064 [1]) to the design of the main control-room (MCR) and a local control-room (LCR). The work is also intended to satisfy regulatory requirements. So far, for the MCR, we have completed a concept design. User requirements clarification involved interviews with stakeholders and visits to similar facilities. Concept design for the MCR was iterative and involved a user reference-group set up for the project. During several workshops, alternatives for layout and workstations were discussed and modelled using 3D graphics. The chosen concept design and 3D model were then checked against standards. The resulting design was approved by the user-group and now goes forward to detailed design and realization. We have also completed detailed design of the LCR so that it is available for commissioning before the MCR is built. IFE also contributes to the human-machine interface design in other projects, such as for alarm system design and a logbook software application.

MAIN CONTROL-ROOM DESIGN PROCESS

Phase A: Clarification

Step 1 of the adopted ISO process [1] is to clarify operational goals, requirements and constraints associated with the design of the control-room. To achieve this clarification, IFE interviewed several of the main stakeholders in the future control-room, and also interviewed some ESS employees with experiences at similar facilities. IFE also visited the Paul Scherrer Institut in Switzerland and Diamond Light Source in the UK to gather operating experience of similar installations.

Interviews for clarification of goals and requirements There was a total of 20 interview sessions covering target control, target cooling, beam physics, beam diagnostics, beam instrumentation, conventional facilities, commissioning, personnel safety (PSS), electrics and I&C, OpenXAL, operations, fire protection, security, control systems infrastructure, cryogenics, alarm design, neutron instruments (NSS) and technical coordination.

The intention was to document results so that identified requirements and constraints could be taken into account. Inputs also included several formal documents supplied by interviewees, and design documents.

The results of the interviews were organized and presented under several topics:

- General requirements and constraints,
- Safety and security,
- Operation and control,
- Specific human factors and ergonomic issues,
- Work organization,
- Work environment,
- Other restrictions and constraints.

Discussion of phase A Phase A resulted in a large amount of interview data and reports from two site visits. All interviews were transcribed from audio files in detail, and as such form a resource for the continuation of the project. The results of these activities are later fed into verification and validation.

Phase B: Scenario Analyses for the Control-Room

Step 2 of the adopted ISO process is to analyse and define operational requirements, in this study in particular to understand the tasks delegated to future control-room operators and other significant users of the control centre, across all modes of system operations. This has led to the adoption of a method based on scenario analysis [2][3] and identification of user-types [4][5]. To reach this understanding, IFE, with the help of a reference group, studied selected operating scenarios and types of future user of the control-room.

Scenario-Based Design The control-room standard ISO 11064 [1] phase B does not state a specific methodology to carry out the "analysis and definition" phase. A traditional approach for a well-specified system would be to use a Hierarchical Task Analysis [6] methodology. As the present system is still in its infancy, we instead decided to use a combination of:

- "User-types", a concept that is based on the idea of "personas" and
- "Scenario-based design" methodology

A user-reference group was created at the beginning of the project involving main stakeholders. A workshop consisting of two half-day sessions was held with the reference group at ESS offices in Lund. Three scenarios were studied: "machine studies", "normal operations with a failure" and "start-up after a long shutdown." Within these, the needs of several "user-types" were characterized: experts, neutron instruments specialists, technicians and engineers, radiation safety officers, and managers.

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Figure 1: Rendering of the approved MCR concept design: "SnabelA" version 2.

Discussion of phase B Results allow recommendations to be made, for example, on the number and placement (work zones) of workstations needed and the main items of equipment to be provided, which together support the main functions and tasks required of the future control-room and its staff. Other issues discussed include large-screen displays, paperwork, procedures, and the working environment.

Phase C: Conceptual Design for the Main Control-Room

The conceptual design stage comprises the design itself, and the approval of the conceptual design [7]. The purpose of this phase is to develop design concepts that satisfy the required functions, tasks, jobs and organizational plans for the MCR that were established in phase B. The conceptual design aims to include:

- Physical attributes of the control centre
- Furnishings and any special amenities
- The proposed operator interfaces
- Proposed communications tools

This phase established the design concepts in context, target specifications and any constraints necessary before proceeding with detailed design. The process aims to result in several design ideas that can be individually appraised and potentially combined, to form an enhanced conceptual design.

Method Design concepts were developed using a two-stage workshop process:

- Exploratory workshop – initial ideas from IFE were presented to the reference group in a workshop format.
- Confirmatory workshop – the strongest ideas from the first workshop were developed to two candidates.

The participation of the reference group of users was essential for the success of these workshops. A "story" with strengths and weakness for each concept was developed beforehand. Comments and design ideas were noted and incorporated or otherwise resolved after the workshops.

At the end of the exploratory workshop, two concepts out of six were selected for further development and presentation to the second workshop. The confirmatory workshop resulted in the unanimous approval by the reference group and IFE. The design is shown in Figure 1.

Conceptual verification and validation The final conceptual design was subjected to a verification and validation check. ISO 11064-7 [8] describes how to verify and validate a control-room design. It is mostly concerned with giving a suitable process for V&V, rather than giving details on how V&V is done. We adopted a qualitative approach covering:

- Applicable standards, e.g., ISO 11064
- Experience from the visit to PSI
- Experience from the visit to DLS
- Results of interviews in phase A
- Results of the analyses of scenarios in phase B

Concept design is followed by detail design and realisation of the MCR. The finished MCR will not be available when beam commissioning starts. Therefore, a commissioning control facility needs to be provided.

DESIGN OF ESS LOCAL CONTROL-ROOM

Space has been allocated for commissioning in the klystron gallery, the "local control-room" (LCR). The cryogenics plants as well as the test stand will also be operated from here [9].

ISBN 978-3-95450-182-3

The LCR must be designed and available before the MCR detailed design and equipment-purchases, so it was important to save design time at this stage of the project. The design team also used its acquired knowledge from the MCR concept design and the standing reference group. This allowed the first two phases of the ISO process to be grouped in a human factor requirement and constraint phase. IFE developed 6 alternative concept designs, which were discussed in a workshop involving all stakeholders. The workshop was successful in reaching a consensus on a balance of human factors requirements and constraints and user requirements and constraints–Figure 2. The workshop was also used to clarify additional needs specific to the LCR.

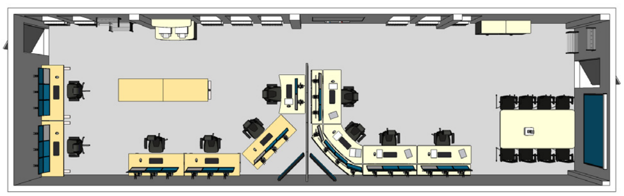

Figure 2: LCR concept selected by the workshop.

The LCR detailed design phase included consideration of control-room siting, control-room arrangement, work station layout and design, sightlines and fields of vision of displays, environmental design, and finally, a verification and validation review of the design based on checklists developed from [8]. The resulting design work (Figure 3) was used to write invitations to tender for supply of LCR equipment. Suppliers have been selected in early 2017, and equipment will be supplied in spring, 2017, in time to allow beam commissioning.

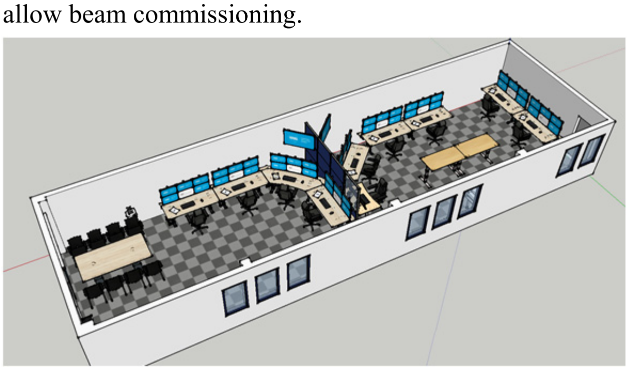

Figure 3: LCR detail design with furniture from selected suppliers

CONCLUSION

IFE and ESS have pursued several design concepts and have identified the needs of a range of users and stakeholders. We have documented the product of design decisions so far, and the process and history of the designs for the LCR and MCR. IFE and the ESS user reference group have together arrived at designs that are good compromises between (sometimes) conflicting requirements.

No one design is the only possible answer. As ISO 11064-2 notes:

> …compromises will be made during the process of the design of a control suite. Many starting points for the design of control suites are possible and a wide range of aspects shall be considered when locating the control suite and rooms within the control suite. [6]

The work now moves to detailed MCR design and co-operation with the building owner and architects as the whole facility is built. The experience with items such as control-room desks in the LCR is useful when applied to the MCR detail design. The continuation of the MCR design will take place together with IFE under the existing in-kind agreement with Norway.

The design work and documentation can also be used to meet a condition from the Swedish regulator SSM [10]: that ESS should report the principles for layout of the control-room and other monitoring and control devices where the interface between personnel and the facility are important for safety.

ACKNOWLEDGEMENT

IFE is indebted to members of the user reference group for making this process possible.

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