From One to Many, from Onsite to Remote: Control Rooms as Diverse Contexts of Use

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Abstract. In many contexts, control rooms are safety-relevant and, from the point of view of HCI research, complex socio-technical systems. This article first summarizes the contributions of the IFIP WG 13.5 Workshop at INTERACT 2023 entitled "On Land, at Sea, and in the Air: Human-Computer Interaction in Safety-Critical Spaces of Control". The process and results of a group work phase during the workshop will then be discussed. A variety of examples (e.g. offshore operation centers, traffic light control rooms) and characteristics (e.g. level of automation, number of operators) in connection with control rooms were identified. Finally, it is pointed out that the diversity of usage contexts should not tempt us to lose sight of cross-domain perspectives, but rather to integrate them through appropriate levels of consideration.

Keywords: Safety-Critical Systems · Control Rooms · Cockpits · Usable Safety · Usable Security · Resilience · Dependability

1 Introduction

The part "on land, at sea, and in the air" in the title of [3] already indicates that "location[s] designed for an entity to be in control of a process" [2] can be found in many contexts and many forms. This diversity and its relevance for consideration in the context of HCI research is also illustrated by the workshop contributions summarized in Sect. 2 and the group activities in the context of the IFIP WG 13.5 Workshop at INTERACT 2023 entitled "On Land, at Sea, and in the Air: Human-Computer Interaction in Safety-Critical Spaces of Control" (see Sect. 3). Finally, conclusions with regard to domain-specific and cross-domain research on spaces of control are summarized.

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2 Workshop Contributions

The authors of the contribution "Towards a Pattern Language for Scalable Interaction Design in Control Rooms as Human-Centered Pervasive Computing Environments", Flegel, Poehler, Van Laerhoven, and Mentler [1], examine the use of reusable solutions to design interaction in control room environments. In most control rooms, demands on operators are increasing and at the same time there is often a lack in support of the operators' tasks, goals and well-being. The authors argue that new technology solutions in this area are often domain-specific and focus on specific functionalities only, so in answer to this they have developed a cross-domain pattern language for control rooms as pervasive computing environments within a human-centered design process. This pattern language consists of eight hierarchical levels, which combine the perspectives of human computer interaction and pervasive computing environments, and is made available for the public through a web-based pattern platform with feedback and comment functions. The contribution ends with a set of discussion points and an outlook on this project.

A paper contribution by Wallmyr and Sitompul entitled "On the Interaction between Construction Vehicles and Humans in Close Cooperation" [6], focuses on the interaction with an increasingly automated robotic workforce, which is typically also working in cooperation with humans for industrial applications. Using the specific example of the construction industry, they illustrate how workers in this industry tend to control specific vehicles such as excavators and mobile cranes as operators. The authors report that it can be observed that such vehicles are increasingly automated, which in turn leads to novel types of interactions where humans work together with robot-like machinery. The authors of this paper then analyze the examples of excavators and mobile cranes and discuss a set of observations, such as the importance of gestures, the need of systems to adapt to new types of actions, and the requirements of such systems being reliable and trustworthy.

In the contribution "Towards Modelling Cooperation in Future Maritime Remote-Control Center" by Saager, Harre, and Hahn [4], the authors identify that the emergence of Maritime Autonomous Systems and Remote-Control Centers poses challenges in understanding and managing cooperation among actors in harbor berthing maneuvers. This paper introduces systematic methods to analyze cooperation from a human factors perspective to provide a basis for investigating these challenges, and provides a review that highlights four key aspects: task analysis, information analysis, social network analysis, and analysis of artifacts and physical layout within the Remote Control Centre and on board the Maritime Autonomous Systems. The authors mention as future work the combination of these methods into an approach and the application of these to the specific use case, to proactively address the increasing complexity of cooperation between all actors involved in the control of Maritime Autonomous Systems. A further aim is to integrate these considerations into the design phase of future Remote Control Centres.

The fourth contribution, "Analyzing Online Videos to Create a List of User Interface Elements: A Case for OpenCrane Design System", by Sitompul, Park, and Alsos [5], presents an ongoing process of developing the OpenCrane design system, which aims to provide open-source user interface elements to build graphical user interfaces for operating cranes. Focusing on remote rubber-tired gantry cranes, which are also known as yard cranes and are used for moving containers, this contribution presents a novel method for creating a list of user interface elements by analyzing online videos published by the crane manufacturers that fully or partially show the crane's graphical user interfaces. By using 11 online videos published by three crane manufacturers that met the authors' selection criteria, the analysis of the online videos resulted in 29 extracted user interface elements. This method's feasibility was evaluated by comparing these results with 27 user interface elements that were elicited from a field study at a port that employed such remote cranes, displaying a significant overlap between the two sets of user interface elements, as well as some differences, indicating the need of both methods a complementary ones.

3 Group Work

This section first explains the workshop procedure. The results of a group work phase by the participants are then discussed.

3.1 Method

After the individual presentation of the workshop contributions summarized in the previous section, the workshop continued with approximately 4 h of group work. An online whiteboard tool (Miro) was used for this purpose because some of the participants were on site and others were connected remotely. First, examples of control rooms were compiled. These were then discussed in terms of their similarities and differences. Based on this, special characteristics and classification options were derived.

3.2 Results

As Fig. 1 shows, the online whiteboard was used extensively and numerous key points and notes were compiled. The following were cited as examples of control rooms or control room-like facilities (see Fig. 2):

– control rooms for wind turbines,
– drone control & UAV control rooms,
– electricity grid control rooms,
– "financial" control rooms,
– control rooms of fire and rescue forces,
– intensive care units,
– offshore operation centers,

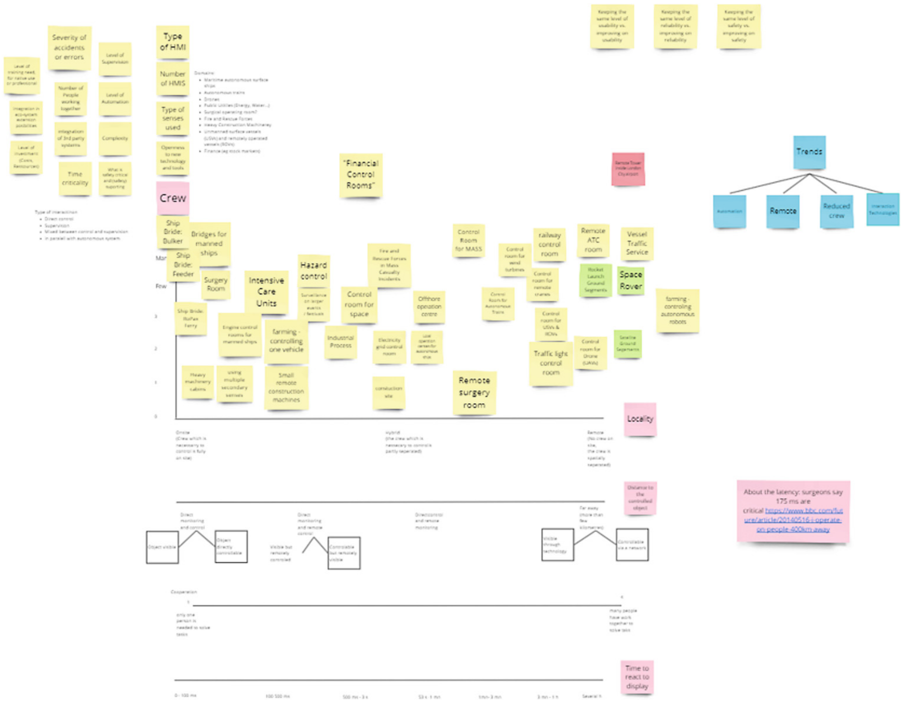

Fig. 1. Overview of the collected and organized contributions of the group work phase

– railway control rooms,
– rocket launch ground segments,
– satellite ground segments,
– ship bridges,
– traffic light control rooms.

With regard to the comparability of these and other control room contexts, various criteria and characteristics were subsequently compiled, including:

– severity of accidents or errors,
– level of supervision,
– level of training need, for native use or professional,
– number of people working together,
– level of automation,
– integration in eco-system and extension possibilities,
– integration of 3rd party systems,
– complexity,
– level of investment (costs, resources),
– what is safety critical and (safety) supporting,
– time criticality,

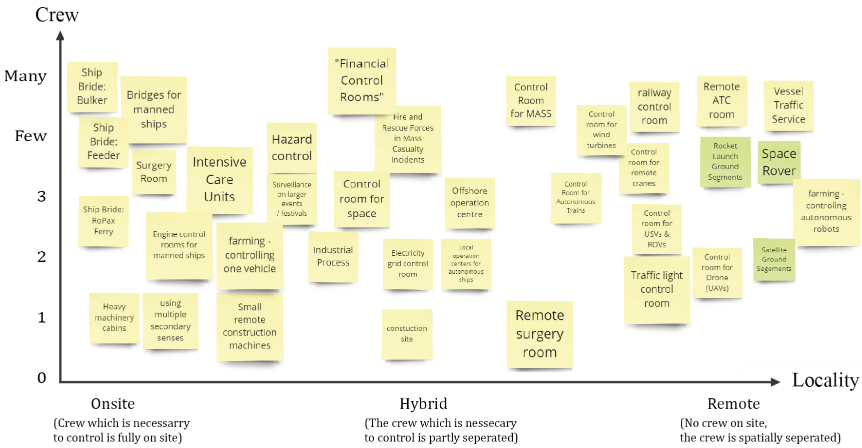

Fig. 2. Overview of the collected control room examples

– type of interaction (direct control, supervision, mixed between control and supervision, in parallel with autonomous system).

This revealed a variety of characteristics, for example with regard to the people involved (one or dozens) or the distance between the control room and the monitored processes (in the immediate vicinity or far away).

4 Conclusion

As can be seen from the workshop contributions and group work, the definition of control rooms as "location[s] designed for an entity to be in control of a process" [2] given at the beginning conceals a variety of specific usage contexts. This applies both with regard to the location (one? several? on site? far away?), the "entity" (one? several?) and many other factors such as the time frame. However, this finding should not lead to the assumption that only domain-specific considerations should be possible with regard to human-computer interaction. Rather, research should be intensified, especially with regard to cross-domain aspects - in recognition of the complexity and specificity of each domain.

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