Towards Control Rooms as Human-Centered Pervasive Computing Environments

Nadine Flegel[1], Jonas Poehler[2[0000-0002-9942-8298]],
Kristof Van Laerhoven[2[0000-0001-5296-5347]] and Tilo Mentler[1[0000-0002-8138-6536]]

[1] Trier University of Applied Sciences, Schneidershof, 54293 Trier, Germany
N.Flegel@hochschule-trier.de
[2] University of Siegen, Adolf-Reichwein-Straße 2a, 57076 Siegen, Germany

Abstract. State-of-the-art control rooms are equipped with a variety of input and output devices in terms of single-user workstations, shared public screens, and multimodal alarm systems. However, operators are bound to and sitting at their respective workstations for the most part of their shifts. Therefore, cooperation efforts are hampered, and physical activity is limited for several hours. Incorporating mobile devices, wearables and sensor technologies could improve on the current mode of operation but must be considered a paradigm shift from control rooms as a collection of technically networked but stationary workstations to control rooms as pervasive computing environments being aware of people and processes. However, based on the reviewed literature, systematic approaches to this paradigm shift taking usability and user experience into account are rare. In this work, we describe a root concept for control rooms as human-centered pervasive computing environments and introduce a framework for developing a wearable assistant as one of the central and novel components. Furthermore, we describe design challenges from a socio-technical perspective based on 9 expert interviews important for further research on pervasive computing environments in safety-critical domains.

Keywords: Control Room, Pervasive Computing Environment, Wearable Assistant, Scalable Interaction Design, Usability, User Experience

1 Introduction

Whether an ambulance is necessary, (air) traffic needs to be managed, a ship must be commanded, or uninterrupted supply of power must be ensured, control rooms, as "location[s] designed for an entity to be in control of a process" [1], are of particular importance for security and well-being of humans in various circumstances of life [2,3,4,5]. Operators bear major responsibility within these critical infrastructures.

While control rooms have changed considerably with respect to information and communication technologies within the last 30 years, operators' work is still characterized by sitting in front of a certain workstation with several screens (private spaces) [4]. While larger wall-mounted screens (public spaces) and central alarm systems facilitate information sharing and group awareness to a certain degree, cooperation efforts are still hampered because operators need to sit at their workstations for major parts of their shifts in order to access information. Furthermore, their physical activity is limited for several hours resulting in fatigue and health issues like musculoskeletal symptoms [6].

Incorporating mobile devices, wearables and sensor technologies could improve on the current mode of operation by enabling more flexible ways of working, e.g., while making decisions in consultation with other control room operators at their workstations or while standing/moving in the control room.

While there are technical issues to solve, e.g., secure wireless connections, this approach must not be seen as a technical challenge of introducing novel hardware and infrastructure only. Rather, it must be considered a paradigm shift from control rooms as a collection of technically networked but stationary workstations to control rooms as pervasive computing environments where people and devices can be mobile and access services in their vicinity with the aid of wireless networking technologies [7,8]. They should complement the existing structures.

To prevent mobility and dynamics from adding complexity to already complex control room environments [9,10], it is important that both people in terms of activities, cognitive loads, and affective states, as well as processes in terms of workflows and modes of operation (routine, emergency) are adequately represented. Therefore, interaction design, usability, and user experience (UX) [11] will be major issues to consider.

After summarizing related work in section 2, we describe a root concept for control rooms as human-centered pervasive computing environments and introduce a framework for a wearable assistant as one of its central and novel components. Part of the framework is a pattern language for scalable interaction design in control rooms (see section 3). Subsequently, method and results of 9 interviews with control room experts regarding our approach are described (see section 4 and 5). Finally, research and development challenges are discussed from a socio-technical perspective (see section 6). These findings can support designers of pervasive computing environments in other safety-critical domains, e.g., intensive care units, operating rooms, or cockpits.

2 Background and Related Work

Human-computer interaction (HCI) and computer-supported cooperative work (CSCW) in control room have been subjects of research for over 30 years [12, 13, 14, 15]. Approaches included workplace studies (e.g., [13, 16]), evaluation of human-centered design activities (e.g. [12, 17]) as well as user interface and interaction design in terms of visualizations [18] or multimodal interaction (touch, gesture, voice) for future workstations [15, 19].

In this regard, blended interaction, a conceptual framework for Post-WIMP interaction design [20], has framed research on “holistic control room design” [21]. By considering four design domains (personal interaction, physical environment, social interaction, and communication/workflow), novel visualization and interaction concepts (e.g., foldable interactive maps) have been elaborated.

Despite the previously mentioned research, a search for “control room[s]” as “pervasive computing environment[s]” showed no results in ACM Digital Library, IEEE Xplore and ScienceDirect (as of May 2021). Search on SpringerLink showed 7 results. Because pervasive computing environments are referred to as smart environments by some [22], "smart control room" was used as a keyword as well (see **Table 1**).

Table 1. Search results for “smart control room[s]” and “controls room[s]” in connection with “pervasive computing environments[s]” in different digital libraries

Library	Keywords	Results (total)
ACM Digital Library	“control room” AND “pervasive computing environment” "smart control room"	4
IEEE Xplore	“control room” AND “pervasive computing environment” "smart control room"	1
ScienceDirect	“control room” AND “pervasive computing environment” "smart control room"	3
SpringerLink	“control room” AND “pervasive computing environment” "smart control room"	14

Search results were checked for relevance regarding human-centeredness mentioned in the introduction by means of their abstracts. If there were direct references to usability, user experience, user interface or interaction design, the contribution was reviewed in full. Results are summarized in **Table 2**.

Table 2. Summary of research on “smart control room[s]” and “control room[s]” in connection with “pervasive computing environment[s]”

Category	Exemplary Research Topics
No or only an indirect connection to control rooms as human-centered pervasive computing environments	Agent-based Peer-to-Peer Systems [23] Automatic Configuration of Camera Systems [24] Control Systems for Smart Meter [25] Economic Modelling [26] E-learning and Training [27] Governance and Ethics of AI Machines [28] Project Classes with Multi-disciplinary Teams [29] Real-Time GPU-Based Voxel Carving [30] Sensor networks in Ubiquitous Healthcare [31] Small Modular Reactors [32]
User interface and interaction design with respect to specific aspects of control rooms as human-centered pervasive computing environments	Gaze-supported Mouse Interaction [33] Multi-display Human-Machine-Interaction [34] Multi-touch Sensitive Displays [35] Open Source, Modularity and Styleguides [4] Quality of UX in Ubiquitous Systems [36] Situation Aware Interaction [37] Smart Collaborative Interface (affordance table) [38]

Systemic or holistic approaches to control rooms as human-centered pervasive computing environments	Human-in-the-Loop Model Predictive Control [39] Tangible Control and Desktop Interaction [40]

In addition, standards like ISO 11064-4:2013 [41] which has been reviewed and confirmed in 2019, describe ergonomic design of control rooms in detail but are “applicable primarily to seated, visual-display-based workstations, although control workstations at which operators stand are also addressed”. It can be concluded that further research on usability of novel control room systems and user experience of operators is required.

3 Control Rooms as Human-Centered Pervasive Computing Environments

The following sections describe our root concept for control rooms as human-centered pervasive computing environments (see section 3.1) and explain the wearable framework approach consisting of two parts: a wearable assistant (see section 3.2) and a pattern language for scalable interaction design in control rooms (see section 3.3).

3.1 Root Concept

According to Rosson & Carroll [42], a root concept represents a “shared understanding of the project's high-level goals”. More specifically, it contains a vision and rationale, groups of people who will be interested or affected and a list of starting assumptions that might have an impact. **Table 3** summarizes these aspects regarding the idea of control rooms as human-centered pervasive computing environments.

Table 3. Root Concept of Controls Rooms as Human-Centered Pervasive Computing Environments

Component	Description
High-Level Vision	Control rooms are human-centered pervasive computing environments being aware of operators’ activities, cognitive load, and affective state as well as workflows and modes of operation.
Basic Rationale	More flexible ways of working are beneficial both for operators’ health/well-being and safe operations in daily routine and in extraordinary situations.
Stakeholder Groups	- Control room operators - Domain experts from different areas related to control rooms, e.g., HCI, information security, process control - Developers of control room systems & applications, e.g., Supervisory Control and Data Acquisition (SCADA)
Starting assumptions	- Operators’ cognitive load and affective states are assessable. - Activities and workflows can be modeled and identified.

One of the main challenges in translating this vision into research prototypes and practical solutions is how to deal with the starting assumptions mentioned before. As will be described in the following two sections, wearable technology, and a pattern language for scalable interaction design in control rooms are key elements to handling them within a human-centered and participatory design process.

3.2 Pattern Language for Scalable Interaction in Control Rooms

Adding mobile devices, wearables, and sensor technologies to control rooms already filled with (stationary) interactive systems could, at worst, make the work of operators more difficult if this were done in the sense of simply offering more opportunities for interaction. Therefore, this challenge can be described as a scalability issue with respect to user interface and interaction design.

We approach this challenge by focusing on the (rather) strict environment of a control room, in which tasks and processes tend to be rigidly set, and represent modes of operation (routine, emergency). Design patterns will be derived within a human-centered design process involving the stakeholders mentioned in **Table 3**.

In this regard, it is worth mentioning that the term design patterns here stand in summary for interaction design patterns as "general repeatable solution[s] to […] commonly-occurring usability problem in interface design or interaction" [43] as well as environmental or behavioral patterns, e.g. cooperative problem-solving [44].

To illustrate this with an example: A reoccurring problem in state-of-the-art control rooms is, that information is provided to many control room operators in different ways at the same time ignoring their individual current workload or affective state. A solution, according to the "load and state balancer"[1] pattern (see **Fig. 1**), could be that the control room operators' cognitive load and affective state (stress in particular) are modelled on an operator-worn computer (see the following section). A dispatcher determines which operator will handle the request based on different policies (e.g., forwarding requests after a short period of time without acknowledgment).

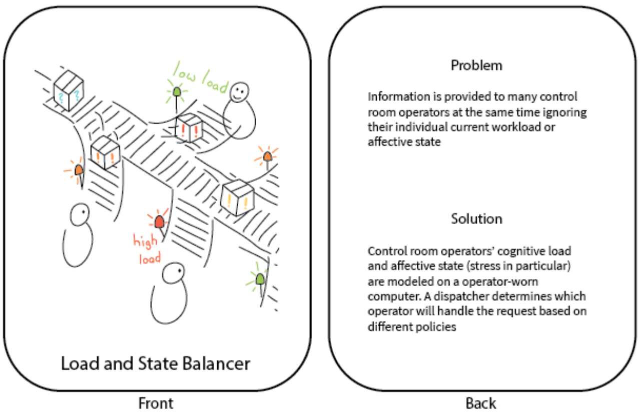

Fig. 1. Draft of a pattern card for the "load and state balancer" pattern

[1] The basic idea is derived from a software engineering design pattern of the same name for scalable systems.

Another conceivable scenario concerns more situation-specific information processing: If an operator is not sitting in front of his/her primary workstation, short-term important messages could be displayed or projected in other formats (e.g., audio signal) or on screens/walls the operator is looking at.

A collection of single design patterns needs to be organized as a pattern language in terms of relationships, purposes, scopes, levels or even contradictions to be an efficient aid for designers. For example, “load and state balancing” might contradict with necessary handling of interrelated sequences of tasks by one operator. A worst-case scenario would be increased coordination efforts or tasks being left undone if assignments were made solely based on individual states. Therefore, operation modes, levels of automation, degree of individual or cooperative work, workflows and available input/output modalities will serve as structural element for the pattern language.

3.3 Wearable Control Room Assistant

Within a wearable framework (see **Fig. 2**), control room operators’ cognitive load and affective state will be modelled on a user-worn computer and used to influence information flow to the operator. The concept of micro-interactions [45] is ideally suited for designing representation and interaction with operators through the wearables, by including the human operator’s cognitive load, stress levels, and current tasks as important resources.

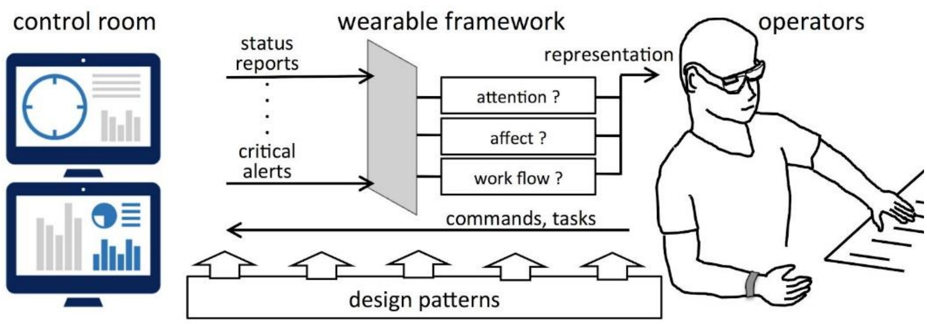

Fig. 2. Overview of the wearable framework, and the way the design patterns affect and influence the selection of an operator, representation of information, and the choice of (micro-)interaction with the help of the individual models.

On the one hand, the framework maintains models for the estimation of the wearer’s attention, affective states (especially stress), and gestures or interaction steps in a workflow, and on the other hand implements the design patterns (see section 3.2) that can be implemented in a wearable system.

Having the attentive and affect models for each of the human operators in place and combined with the model for the tasks at hand, the wearable assistant can respond in a more informed manner to events according to the most crucial information features in the control room, by presenting situation-tailored feedback, e.g., alarms and other control room events, appropriately. The workflow model, however, is relevant to logging tasks as detected by the operator's wearable setup.

A wearable feedback effort follows the model designs, in which the wearable framework can be integrated into the control room functionalities to display appropriate, situation-dependent information and alerts as guided by the design patterns.

4 Methods

In the following, details of semi-structured interviews with 9 control room operators and researchers on HCI/human factors (HF) in safety-critical systems from different countries[2] are described (see **Table 4**).

They were selected and solicited based on relevant publications, appropriate public appearances (talks, interviews), or leadership positions in professional bodies. Participants (3 female, 6 male) were interviewed to discuss potentials and challenges on future control rooms (30 - 40 minutes; recorded videoconference sessions). They were asked about the state-of-the-art of digitalization in control rooms, digital assistance systems in control rooms and their opinion about control rooms as human-centered pervasive computing environments.

Table 4. Overview of participants' working areas and years of experience.

ID	Area (Research / Industry)	Years of experience regarding control rooms
1	Research on maritime safety-critical systems – HCI/HF, with work experience on ship bridges as a captain	20
2	Research in technical ship navigation with work experience on ship bridges as a captain	40
3	Work experience on ship bridges as a captain	18
4	Head of fire and rescue control center	10
5	Research on safety-critical systems – HCI/HF	> 30
6	Research on safety-critical systems – HCI/HF	20
7	Research on maritime safety-critical systems – HCI/HF	10
8	Operator in control room of fire and rescue forces	12
9	Research on safety-critical systems - HCI/HF	>22

Interviews were structured in 5 categories (see **Table 5**) involving questions asked to both groups and questions asked to one of the groups only, e.g., practitioners about work experience in control rooms. Two participants (ID 1 & 2) belong to both groups, because they have professional practical experience as well as research experience.

[2] For reasons of anonymity, a more precise assignment is omitted because identification of participations would be possible easily in some cases by combining work area, years of experience, gender, and location/nationality.

Table 5: Semi-structured interview guide for researchers (R) / control room operators (O)

Category	**Example questions**
Both: Work experience	How many years have you been working in the domain of [control rooms | HCI/HF/safety-critical systems]?
R: Research on safety-critical systems O: Work/Tasks in Control Rooms	Are you aware of any training activities or performance indicators of professionals on the job (observable by technology)? Are you aware of any health- /well-being related activities (e.g., relaxation exercises) that are carried out on the job?
R: User Experience & Usability of digital systems in safety-critical domains O: Digitalization in Control Rooms	How do you assess the state of digitalization in [control rooms | safety-critical domains]? Where is the most "digitalization potential"? What role has UX in safety-critical systems?
Both: Digital Assistance Systems in safety-critical domains – State-of-the-Art	Are you aware of any mobile or wearable devices or sensor technologies? What would be your expectations of a body-worn computer system to be used in everyday professional life in the control center?
R: User-Centered Pervasive Computing Environments O: Future of digital assistance systems in control rooms	Are there situations/scenarios (experience from related projects/approaches) in which you could imagine meaningful support through such and other technical solutions. Scenario 1: Distribution of tasks according to individually measured workload? Scenario 2: Support of closer cooperation through appropriate processing of messages/alerts?

Participants received a short introduction to the topic of pervasive computing (environments). The 2 previously mentioned scenarios (see section 3.3) served as illustrations. At the end of the interview, participants could provide comments and open questions. Recorded interviews were transcribed and analyzed by themes/topics. Results are summarized in the following section.

5 Results

From the point of view of the experts interviewed there are potentials but also challenges and concerns with respect to our vision of control rooms as human-centered pervasive computing environments. To structure the feedback, the concept of human, technology, and organization (HTO) served as a template. Complemented by societal and cultural aspects (environment in a more general sense), it offers a framework for understanding working environments as socio-technical systems [46, 47].

The following sections describe results according to workflows and user experience ("human"); wearables, mobile devices and sensor technologies ("technology"); performance and health ("organization"); and social and cultural aspects ("environment").

5.1 Workflows & User Experience ("Human")

In this section, feedback on the 2 scenarios ("load and state balancing", more appropriate processing of messages/alerts) and user experience of control rooms as human-centered pervasive computing environments in general is summarized.

First, all participants stated that considering user experience going beyond usability in terms of actions, beliefs, emotions, preferences, and perceptions occurring from before to after usage [11] is advisable but has been rarely done in safety-critical domains yet. One expert stated that "You get the most out of people, you get the best performance out of people" (ID 5), if you pay attention to user experience. And not just in the control system design and how you interact with it, but in the whole working environment. Lighting, windows, colors, etc., a "calming environment" are important.

One expert (ID 4) sees high potential in the "load and state balancing" scenario because practical experience showed that operators often do not even notice that they need help and are in state of cognitive overload: "We do this human factor training, I already said that, and the idea behind it is that you notice I'm overworked, and I raise my hand and say I need help. That doesn't work because the employees don't understand [...] they don't notice [...] and the manager behind them doesn't notice either."

For the second scenario of more appropriate processing of messages/alerts, feedback was diverse. On the one hand, potential to increase flexibility of workflows has been assessed. An operator (ID 3) with 18 years of experience in different control rooms pointed out, as an example, that although there are redundancies in the displays on large ships, e.g., 4 monitors on the ship's bridge showing the same values, in some situations, such as the ship docking in port, some data is not available because you are not located near these screens during this process. "When a ship docks and you are in one side of the ship, [...] and there you are really like in a small room, in order to have an overview of the entire length of the ship [...] then a kind of visualization would suffice that perhaps shows the distances or a water stream or the wind sensors again or a speed through the water, so that I have simply shown certain data again, which until now have been integrated in a complicated way in a monitor."

However, some experts also pointed out that this scenario would only work under certain conditions. The system must have a carefully designed, context-aware, alarm management, so that only the important information is displayed and there is no flood of alarms and information massages, which is still a problem in many domains.

The way and form how the technology is provided could play a major role in the acceptance by control room operators. Experts were asked about their opinion about a "clearly visible vs. unobtrusive" way of integrating cameras and sensor technologies into a control room. Most of the experts said, that a camera, that looks like an ordinary security camera, wouldn't be good, because cameras are associated with supervision in control room settings and that would reflect on getting the information to human resources department, so it shouldn't look like an ordinary camera was the most frequently mentioned answer on that question: “I would say that cameras are always negative. Well, because you always feel like you are being observed, and you always know them from our environment as supervision cameras and stuff like that. If it disappears into a buttonhole and is not perceptible, then maybe the way we deal with it is completely different.” (ID 4).

However, operators need to be informed where cameras are located and what area they cover in the control room and what happens with the data: “This is always a very sensitive topic when it comes to supervision. Where perhaps there would also be strong concerns. People say I'm being permanently monitored here, so I think you have to sell that very well to the people and also accompany them and tell them exactly what is being done with the data, because otherwise I think there are very big concerns.” (ID 8). This expert said that it would be better to have clearly visible cameras.

5.2 Wearables, Mobile Devices & Sensors (“Technology”)

In this section the results of state-of-the-art of wearables, mobile devices and sensor technologies in control rooms are summarized and challenges with respect to the technical view are described.

Experts were asked, if they were aware of any wearables, mobile devices or sensors technologies used in state-of-the-art control rooms. Up to their knowledge, there are hardly any of these devices used in control rooms. One exception was a tablet called Portable Pilot Unit (ID 7) used by operators on ship bridges in Germany to communicate with each other and to have synchronized information between themselves and their station.

The experts were also asked if they are aware of any sensor technology that detects presence and health conditions of operators in the control room. In many domains, there is a requirement that control rooms must always be manned by at least one or two people. Sensors could measure whether the control room is really manned and whether there is a medical emergency. However, the experts stated there are no known sensor that measure things like that.

On the one hand, experts see potential to make workflows more flexible with mobiles and wearables and to use sensors for the safety of the overall process (see section 5.1). On the other hand, a reoccurring pattern in the interviews was concerns about security risks. Representatives of both groups expressed concerns about devices and sensors that are highly connected and work wirelessly. One expert belonging to both groups (ID 1) stated that “the more you connect stuff the more you open up yourself to cyber risks. […] nothing on board is protected for that. Everything is very vulnerable and open to attacks and then even systems that we don't have on board, but we sort of use sensors there everything can be hacked and spoofed, so that's probably a lot of risk.”.

Obviously, security is an important factor that must always be considered when developing for safety-critical systems: “There is no safety without security” (ID 9). Otherwise, these developments will not be able to be used in the real environment, as an expert on HCI in safety-critical domains pointed out. It is important to investigate what could support peoples' activities with respect to new technologies and new ways of interacting, but the solution must be stable, functioning and fulfill and pass security requirements before it can be integrated into a safety-critical system.

5.3 Performance, Mental & Physical Health ("Organization")

The results addressing the awareness of accessibility or inclusive-/ability-based design or health- or well-being related activities (e.g., relaxation exercises) that are carried out by professionals (on the job) show, that there is hardly anything known, except shorter shifts, more breaks, opportunities for movement to support the health of the operators. But that is, according to a head of a fire and rescue control center (ID 4) something which a lot of thought is being given and solutions sought: "Well, that's really astonishing. I have not observed anything that they do. So, this is also a topic that we have on the agenda again and again. [...] They are simply overloaded. [...] Unfortunately, there is nothing good, or we haven't found anything yet, to prepare the staff for something like that".

Another question was, if the experts are aware of any training activities or performance indicators of professionals on the job (observed by the control room system itself), because these measurements would be interesting, to investigate how the control room as a human-centered pervasive computing environment could distinguish certain events or behaviors to support operators. Experts said that such things would only exist in predefined training scenarios in control room simulators but not during real operations.

Experts were also asked, if they are aware of accessibility or inclusive-/ability-based design in safety-critical domains, like individual focus on the operator, so that in the control room setting the application somehow vary depending on the individual person. Taking a strong focus on what the single operator as a person is good at or not good up to physical activities but also mental (very good in problem-solving vs. very good in decision-making). But there is also little known.

One of the experts (ID 8) pointed out a major potential advantage of the first scenario: „ Because in the end it is always an important factor for the argumentation when one says, I need more staff. That concerns the superiors. Of course, they ask for reliable data. […] Why do you need a fourth man or woman? What did the three of them do? Were they all working at full capacity all the time? If you can back that up with hard facts, […] say here, the people who are all present at the same time, they all already had a certain stress level with certain tasks. Maybe not just once a day, but on a regular basis. Then I think that is the best argument to make to the decision-makers. This can only be said in the public sector via the political track, and we have a need for personnel because otherwise we are simply endangering the health of our employees."

5.4 Social & Cultural Aspects ("Environment")

According to an expert (ID 3) who has worked on passenger ships with international crews, there are major cultural differences in the assessment of cameras and surveillance and how to deal with them: “For a part of the person, maybe even in America, it's normal. There are cameras everywhere, but for the Germans it was really a huge thing at first [...] - this feeling of always being under control and so on. On the other hand, if you say: Yes, and it serves safety, if something happens, you can understand that.”

The role of user experience, if aspects like aesthetics and positive emotions, being proud on your workstation contribute to the safety and dependability of the overall system, might differ in control room domains. There is a difference in control rooms which are physically separated from the system, being controlled (e.g., fire and rescue services, energy control rooms) and control rooms which are physically integrated in the system (e.g., aircraft cockpit, ship bridge). In the latter, it is a requirement, to record conversations. One expert (ID 2) said that some shipping companies forbid private conversations on the ship bridge, which does not work, because the ship crew usually live together on the ship for several weeks to months, and the ship bridge is not only the control center but also the first meeting place for the team, during breaks to drink coffee, chat, etc., which is important for the crew on board. The expert said that some shipping companies only see the people’s role as professionals and forgot that they are human beings, therefore these UX issues sometimes get minor attention.

6 Discussion

The results of the expert interviews show that the vision of control rooms as human-centered pervasive computing environments is promising but associated with numerous challenges of a socio-technical nature. They involve human, technical, organizational, and environmental aspects.

Interactions between control room operators, mobile and stationary technology, control operations and the wider environment must be carefully considered. For example, the development of a wearable assistant is not just a matter of data models and algorithms but equally a question of user interface and interaction design within certain professional cultures (e.g., “camera look equals surveillance”). This also shows that user-related considerations must not be restricted to the usability factor but must be holistic in the sense of user experience. Enabling operators to move within in the control room without losing connection to their work could be beneficial in various ways from health management to cooperation efforts. In total, this could improve process control.

6.1 Limitations

Even though the participants have years to decades of experience with relation to control room environments, results must be evaluated cautiously due to the small sample and different work domains. Challenges described before should not be understood as a conclusive list. However, they can serve as a starting point for further research and development on safety-critical pervasive computing environments.

The views of the other stakeholder groups described in section 3.1 have also not (yet) been considered to a sufficient extent at this point. In further exchanges with control room operators and developers of control room systems/applications, possible additions and contradictions will have to be incorporated.

In addition, a root concept was introduced, the concrete realization of which is still pending. However, it has already been started and builds on established research findings in the areas of HCI and pervasive computing.

6.2 Conclusions

In this paper, we have presented a root concept for control rooms as human-centered pervasive computing environments. We have introduced the concept of a wearable assistant as one of the central components of such environments and proposed work-related design patterns as a solution to the scalable interaction design challenge resulting from the integration of wearables, mobile devices, and sensor technologies. Interviews with 9 control room experts from research and practice showed that there are several challenges related to humans (operators), technology, organization and (social) environment to solve.

To involve one of the stakeholder groups which have not been considered so far, a questionnaire on digitalization and workflows in control rooms as well as the vision of control rooms as human-centered pervasive computing environments has been created. By the beginning of May 2021, more than 120 control room operators have already participated – many of them open for follow-up interviews. In this regard, user experience research will be based on the question: Do control room operators perceive a portable assistant based on design patterns as paternalism (in terms of autonomy and expertise) or support (in terms of safety)?

Development of the interaction design patterns as a comprehensive collection of single design patterns will follows a participatory approach with feedback by control room experts passing different states (e.g., applied pattern, approved pattern). Pattern candidates have already been derived from a literature review on software engineering patterns for scalability in terms of performance and technical reliability.

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