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From desk to field - Human factor issues in remote monitoring and controlling of autonomous unmanned vessels

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Abstract

Autonomous vehicle and drones have become more popular in recent years whereas unmanned merchant vessels remain a less-matured concept. The MUNIN project examines the feasibility of autonomous unmanned vessel that is concurrently monitored by an operator onshore. Previous research suggests maintaining adequate situation awareness as a primary challenge related to human-center automation. The purpose of this study was to identify the human factor issues in remote monitoring and controlling of autonomous unmanned vessels through scenario-based trials by four master mariners and a ship engineer. The literature review and fieldwork data identified gaps in the current system corresponding with changes in a harmony framework, suggesting aspects on which the design could be improved to enhance operator's situation awareness and regain harmony onshore.

Peer-review under responsibility of AHFE Conference

Keywords: Harmony; Situation awarenss; Shore Control Center; Alarm management; Decision-making; Human-center automation

1. Introduction

Nomenclature

OCT	Onboard Control Team
SA	Situation Awareness
SCC	Shore Control Center

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Autonomous vehicle and drones have become much more popular, having been used in many military, coastline monitoring and offshore exploration activities. However unmanned merchant vessels have yet been mature to a point to consider mass utilization and deployment. MUNIN (Maritime Unmanned Navigation through Intelligence in Networks) is a European Union project that examines the feasibility of autonomous unmanned vessels and their human-center automation governance from shore-based facilities during intercontinental deep-sea voyages. The unmanned vessel paradigm should result in a better onshore working environment, increased safety for seafarers, as well as reduced environment impact as an outcome of a slow steaming strategy.

Considered in the MUNIN paradigm, an autonomous unmanned dry bulk carrier is controlled by an automated autonomous ship controller that is concurrently monitored by an operator at a Shore Control Center, SCC. Previous studies on human factors have identified several challenging aspects related to human-center automation and ship handling as they relate to the design of the SCC. One problem of remote automation is to keep adequate Situational Awareness [1], SA, which is "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" [2]. On a manned ship, ship handers constantly build their SA. How the onshore operators develop their SA remains yet to be elucidated upon.

Ship handling is a dynamic and complex activity. The crewmembers traditionally rely on visual information from the environment (e.g. available water or wave direction) and navigational instruments (e.g. ECDIS or radar). Spatial movement of the vessel (e.g. slamming, rolling, heaving or pitching) plus the feeling towards the vessel's inertial performance with relation to maneuverability all contribute to the decisions made regarding ship handling. These cues contribute to a ship handler's "ship sense"[3], a skill behind the concept of "harmony". Harmony is composed of environmental prerequisites (context and situation), vessel specific prerequisites (inertia and navigational instrument) and personal prerequisites (spatial awareness, theoretical knowledge and experience) [4, 5]. A ship handler relies on various information sources to strive for harmony between the vessel and the environment, although the effort and weight differs depending on the context and situation [5]. Due to the nature of geographical separation of the SCC from the vessels, information is likely to be presented digitally on computer screens. A lot of cues the operator uses when navigating on board and making decisions is lacking. Both SA and the creation and maintaining of harmony might face severe challenges [6].

The purpose of the study was to identify the human factor issues related to the SCC: what are the gaps that prevent an individual or even the team in achieving adequate SA to make appropriate decisions. A two-day scenario-based fieldwork study in a virtual shore-based system prototype was used to clarify these human factor issues. The findings may better shape human factor knowledge and design principles to allow operators to manage information effectively, in order to obtain a high level of understanding of what is happening to the unmanned vessels at sea.

2. Methodology

2.1. Participant demographics

Five participants (4 males with backgrounds as master mariners and 1 female engineer) were invited to take part in the scenario-based trials and debriefing interviews. Their ages ranged from 28 to 49 years with a mean age 39 ($SD = 8.9$) years. Previous experience at sea varied between 3 to 18.3 years, with a mean period of 10 ($SD = 6.8$) years. For the four master mariners, their time as a deck officer ranged from 2.4 to 8.6 years, with a mean of 5 ($SD = 2.5$) years. All four master mariners had experience in navigating ships in a simulated environment. All participants signed a written consent form about the anonymous and ethical usage of their data. They were assigned different IDs (1-5) to act as the operator, captain and engineer in scenarios.

2.2. Description of the Shore Control Centre

The manning of the SCC consists of a supervisor, captains, engineers and operators. The operators are the backbone of the SCC. Each operator is required to monitor 6 unmanned vessels via a monitoring and controlling workstation (see Fig. 1), which is comprised of 6 dashboards (one per vessel, top and bottom middle), a customized electronic sea chart (bottom left), and a conning display (bottom right) and a weather chart (top right). During most

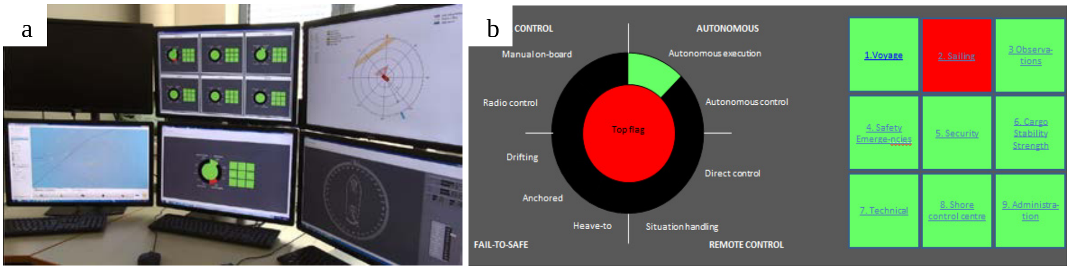

Fig. 1. (a) the operator's work station; (b) one dashboard to display 9 group information from one unmanned ship.

of an intercontinental voyage, ships are autonomously controlled by their on-board computerized system and regularly send information to the SCC operator for monitoring purposes. One operator can check the overall status of all 6 vessels, as well as, categorized and monitor information from each vessel by cycling through each of the 6 dashboards. On the top "layer" of each dashboard there are 9 information panels an operator can explore to discover more specific information about a control process (see Fig. 1). Each information panel in the dashboard has a color flag as the top flag: Green, Yellow or Red. If everything is operating normally or there is no impending threat, then all 9 top flags in the dashboards shall show green flags. If some values on a ship diverge from the pre-set threshold and the autonomous ship controller is incapable of correcting, the system will call for help by sending either Yellow or Red flag to the SCC to alert the operator of an abnormality. Yellow stands for a non-critical situation that might not require immediate intervention but only the operator's attention. A Red Flag on the dashboard stands for a critical situation within a certain operational category. In Fig. 1, the top-layer category panel "*Sailing*" indicates a Red Flag, which requires the operator to investigate through deeper information layers and take corrective actions immediately. Typically the onboard autonomous ship controller controls the unmanned vessel as per a pre-voyage plan. In order to address the growing governance issue for managing the disparity between control and accountability in a complex automated system [7], a modes viewer has been designed in the top-layer user interface to display which mode the vessel is operating, as the circles beside the dashboard show in Fig. 1. The modes include *autonomous* (*autonomous execution* where the ship follows a predefined track and speed plus *autonomous control* where she could automatically manoeuver for collision avoidance or re-route due to weather), *remote control* where the ship was completely under the command of the SCC, *fail-to-safe* and *manual control*.

Beside the operator, the SCC is structured to include other roles (i.e. the supervisor, captain, and engineer). The operator may use existing workstation-based navigational instruments to solve a Red Flag issue, such as the sea chart and conning display, or request additional help via the SCC supervisor. The task of organizing the operator's workload, for example by reallocating resources within the SCC, is the responsibility of the supervisor. In these trials, it is the supervisor's job to call upon the captain and/or the engineer. The captain who has considerable seagoing experience is the head of the division and should be legally responsible for the activities of each vessel under the SCC command. It is hypothesized that the captain shall make the final decision, similar to the captain on a traditional vessel. When the situation requires navigational operation from the SCC it is expected that the operator and captain in charge will go into the situation handling room where they can conduct precise ship handling with a joystick on a projected sea chart (although it is possible to change the ship's speed and course through the sea chart and conning display at the operator's workstation). If it comes to technical issues, the experienced and licensed ship engineer would be called upon by the supervisor to provide knowledge and experience about onboard equipment such as engines, auxiliary power stations, thruster, steering pumps. Once the operator requests help via the supervisor, he needs to assist the captain and/or engineer with all information known about the situation. All these functions are done within a simulated environment for the purpose of proofs of concept.

2.3. Experimental design, tasks and procedures

Five scenarios, developed by subject matter experts, were presented to the participants over a two-day period. These scenarios were used to assess the functionalities of the SCC prototype system and the performance of the participants while they undertook various SCC roles (i.e. the operator, the captain and the system engineer).

Table 1. Role assignment by participant

Roles in the SCC	Engine I: pump injection failure	Engine II: carry water overflow	Collision avoidance	Heavy weather	Precise manoeuvring and crew change
Operator	1	3	2	3	4
Captain	4	2	1	4	3
Engineer	5	5	X	X	X

- Engine scenario I & II: The operator is informed by the dashboard of a yellow alarm message that a malfunction of the injection pump / carry water overflow has occurred.
- Heavy weather: The operator is informed by the dashboard of a yellow flag first and then a critical situation (red flag) arises. The weather routing module is evoked but fails.
- Collision avoidance scenario: A target ship does not fulfil COLREG obligations; the operator receives the notification with a red flag.
- Precise manoeuvring and crew change: The operator should assist the captain to plan for a rendezvous with the Onboard Control Team, OCT, in preparation for an inbound port approach. The captain should conduct precise manoeuvring through a channel to the anchored position and transfer the ship control to the OCT onboard.

In Table 1, the scenarios are listed from left to right in a chronological order while the number is the assigned participant's ID. "X" means this role was not needed in the scenario. Except for the participant with the engineering background, the others could assume both the operator and captain at least one time through the two-day trials. Considering the supervisor's task is to reallocating resources when the operator requests help, the project consortium decides to use one project member to act as the supervisor in order to make sure the scenarios didn't stray too far from the original objectives, while not unnecessarily influencing the participant's behaviours and decision-making.

Prior to the data collection, all participants were given approximately 2 hours of familiarization information, including half an hour briefing on duties and responsibilities of personnel in SCC. This was followed by an introductory presentation about the overall concept of unmanned ship and the modules in SCC. Each participant had approximately one hour of further instruction and individual practice on the technical system. All scenarios and post-scenario interviews were recorded by a video recorder for further analyses. Direct observation approach by an onlooker observer was used and field notes were documented [8]. All participants in the scenario were encouraged to "think-out-loud" [9]. After each scenario, the participants were asked standardized open-ended interview questions. Questions were developed for the exploration of the participant's sense making process, behaviors, opinions about the team performance, as well as identification of usability problems from the perspective of human computer interaction [10], based on the preliminary findings of operating ashore for unmanned ships [6].

2.4. Data analysis approach

The analysis was done based on the literature review of the concepts of ship handling for harmony [4, 5], the model of SA in dynamic decision making [2, 11-13] and SA-oriented design [11]. It identified several inconsistencies in SA requirement as underpinnings for the next round of comparative analysis using Grounded Theory [14]. MAXQDA 10, a computer analysis assistance tool was used for qualitative text analysis [14, 15]. The existing frameworks, memo and diagrams obtained from the portrayal of relationships between emerging concepts were constantly compared to generate explanatory propositions that correspond to the scenario performance and in the interviews. The comparative analysis integrated the open coding with axial coding, which identified variations in the pattern. The elaborating of paradigm fostered the higher-level categorization and theorizing.

3. Results

3.1. Connection between harmony and SA in the SCC

Harmony can be seen as a balancing act between the ship handler's capabilities and the task demands conducted by the vessel. But how harmony relates with SA both aboard and ashore has not been studied. The three levels of SA refer to perception, comprehension and projection [2]. By directly perceiving the elements from the overall context,

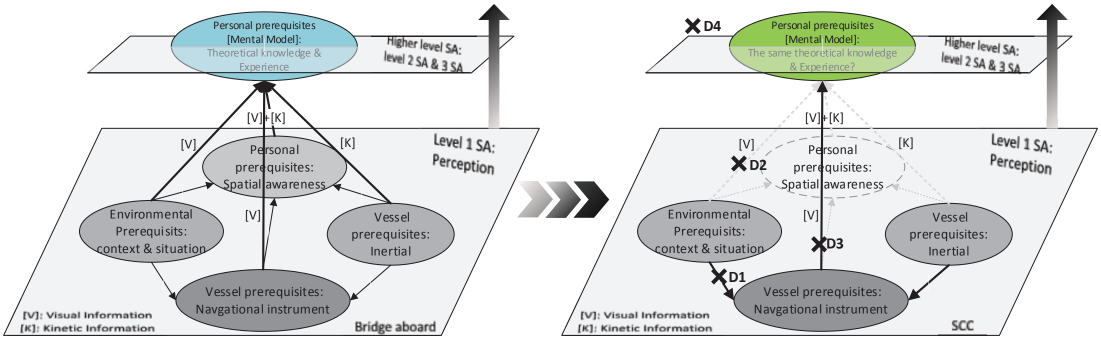

Fig. 2. (a) tetrahedral model adapted from harmony [4]; (b) four discrepancies are identified for further analysis.

the onboard ship handler achieves level 1 SA. He constantly uses the mental model as a higher-level SA enabler (e.g. theoretical knowledge and experience) to interpret the surrounding perceptual information and understand how things are working and evolving in the situation. The relation between SA and constituents of harmony is structured in an adapted tetrahedral model in Fig. 2(a). In the SCC, the officer of the watch was assumed to be the operator to monitor unmanned vessels and take over control if necessary. The result showed that besides the difference in the operational concept, the comparative analysis gave evidence of four other discrepancies (D1-D4) in SA requirement [11] in light of the changing harmony depicted in Fig. 2(b):

- D1: All information about environmental context, situation and the vessel's inertial performance can only be remotely collected by the sensor technology and then transferred to the SCC. Considering the detection of external cues is the prerequisites for level 1 SA, the *technology analysis* needs to be reconsidered to ensure the selected technology meet the needs of sensing objects and necessary data communications.
- D2: The operator cannot feel the same spatial movement of the vessel or inertial, nor directly perceive contextual information. It indicates enormous changes to the *environmental conditions*. The static office environment has largely restrained the perceptive capabilities of the operator to achieve level 1 SA and even higher level SA.
- D3: The operator can only perceive external cues about the environmental context, situation and vessel's inertial performance through multiple sets of navigational instruments, surrogates for the single visual information input source. Scanning, monitoring and mapping activities to different screens would likely become the main tasks. It indicates the need to conduct a cognitive task analysis to clarify the adapted *operational requirements.*
- D4: Although it is assumed that the operator has navigational experience, they are not necessarily taking the same types of physical and cognitive process they employed onboard, which brings to question the *operational requirements* and *the user's characteristics*. Together with D3, operators will assumedly face critical challenges to achieve high level SA without proper training and adaptation.

3.2. Discrepancies in relation with gaps, SA requirement, SA and barriers in the system design

The discrepancies in the requirement analysis and technologies analysis uncover the changes in the SA requirements [11] and therefore indicates gaps in the design of a shore-based monitoring and controlling system based upon more traditional bridge design principles, as the operators are not originally "situated" in the loop. They present the variations for further comparative analysis on the data from the interview. The manuscripts from the debriefings not only confirmed gaps that could impede the operator's individual SA but also identified new gaps that could also fail team SA [11, 12, 16]. These gaps are not isolated but correlated (see Table 2).

By delving into the transcripts from the post-trial interviews and scenario recordings, the analysis revealed that (1) how these gaps likely hindered the operator's SA development; (2) what aspect of the system design contributed to these gaps (See Fig. 3).

Table 2. Relations among discrepancies, gaps, SA requirements, affected SA, barriers in the system design.

Discrepancies	D1	D2	D3	D4	Newly identified D5
Gaps	Detection of abnormity and generation of the alarm	Loss of ship sense	Generally passive monitoring pattern	The adaptation of the mental model	The organizational hierarchy and regulations
Impact on SA	External cues	Level 1, 2 SA	Level 1, 2 SA	Level 2, 3 SA	Team SA
SA requirement	Technology analysis	Environmental conditions	Operational requirement	Operational requirements and the user's characteristics	Operational requirements
Barriers in the system design for future improvement	Alarming	Alarming, information support, interface design	Alarming, information support, interface design	Alarming, interface design, cooperation	Alarming, interface design, cooperation communication

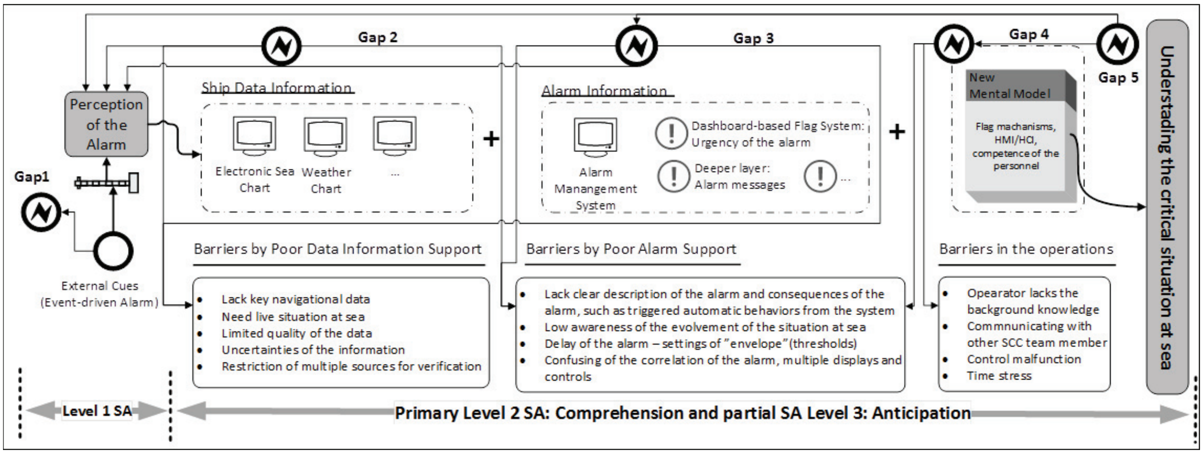

Fig. 3. Gaps and barriers that prevented the operator from achieving sufficient SA in the SCC.

For each operator, the process of information handling consists of two phases. The first phase is before perception of the situation (reaching level 1 SA). The detection failure in Gap 1, the geographical separation from the environment in Gap 2, interaction issues in Gap 3 and unaccommodated status in Gap 4 led to the phenomena in scenarios that there would be either no alarm at all when there should be, nor the operator almost failed to perceive the alarm from the screen – "*If there is no audio with the alarm, we probably would miss it*". The video also revealed that one operator missed the alarm because of the vision tunneling and distraction caused by multi-tasking.
The second phase is after perception of the situation (reaching level 2 or even level 3 SA). The operator's SA was decayed due to the barriers in the information support and practical operation. The analysis revealed that the operator felt it difficult to verify emerging information (Gap 2) such as "*we need to see the real situation such as CCTV onboard combined with audio equipment…here we don't feel the wave, the sound of the engines*". They couldn't obtain how the situation was evolving without knowing the alarm's limitation and tendency (Gap 3) – "*things happen so fast…I didn't have the sense of the urgency*". Inappropriate alarm thresholds configuration caused the observed alarm delay, which led to severe stress – "*The alarm didn't give us a proper time to react*". Complexity in the new system, uncertainties towards the environment, some technical malfunction in the user interfaces, together with the knowledge gap resulted in an errant mental model among operators (Gap 4).

What further deteriorated the situation is Gap 5, hidden in the organizational hierarchy and regulations. When there was an engine failure, the operator who lacked the technical competence realized soon that he should request the engineer's help via the supervisor as per the scenario's standing orders. But in the collision avoidance scenario the operator held his help request as he admitted that "*I called the captain late*". He believed it could be resolved with his competence. Either case, time was used efficiently. A combination of all these gaps caused time stress -"*the system creates panic*" as one participant described. Firstly the operator spent more time in investigation than attending to the situation aboard. Secondly there was no regulation saying that the operator must request help under what conditions. Thirdly the captain was initially out of loop and could only develop the SA via communication and shared displays, which further prolonged the time to resolve urgent issues. All these undermined the team SA resulting in the degradation of team performance and the decision-making capabilities. Generally speaking, the human factor issues emerged from the current prototype system made the participants feel hard to understand how critical the situation was at sea and how it would evolve in the future.

4. Discussion

The assumption that the technology, competences and organization can be located ashore is challenged by the results. It is a fact that some technical glitches in the system influenced the operator and the team' performance and decision making as some software modules were still under development at the time of the trials. In addition, there were practical test resource limitations in terms of the training time as well as the number of participants and scenarios. Still, the study collected empirical data for an envisaged work analysis, explored the outstanding human factor issues with regard to monitoring and controlling unmanned vessels in a shore-based environment. The field study provided a leverage point for discussion about the sociotechnical system design.

Apparently the alarm management system is the most important medium ashore in the SCC to both trigger actions onshore when there is automation failure onboard and keeps the operators in the loop for further decisions and actions. The current prototype is basically structured as a color-flag-based qualitative information report system integrated with other conventional navigational instruments, such as the sea chart. In principle this approach enables the participants to check the overall status of multiple vessels by quickly scanning through the top-layered flags, and then assist the investigation with their familiar navigational instruments. Some of the operators reported they felt the situation would evolve to a red flag, which implied that minor parts of level 3 SA could be achieved. Nevertheless, the SA requirement analysis from Table 2 and gap analysis from Fig. 3 revealed the technological risks to have "old wine poured into new bottle" because the loss of the harmony does not only indicate a negative impact upon perception (lower level SA), but also means the degraded ability to foresee the situation (higher level SA). The shore-based operators were not in the loop *per se* without ship sense while the officer of watch can actively monitor the evolvement of the situation. This implies that the design of the alarm system ashore shall adopt a much more proactive approach than the way done onboard because the shore-based operator/team needs more time to react, develop SA and get into the loop. The onboard thresholds of the alarms are not necessarily suitable for the situation of remote monitoring. The alarm shall have properties related to the "tendency" of the event in order to facilitate the operator's SA effectively and efficiently, rather than providing a three color based information system. More types of information (e.g. visual/audio) should be available in the SCC in a proper manner (e.g. vibrating hardware or haptic devices) to actively engage people and support them for further verification and decision-making.

What the project team previously assumed about the operator's competencies is also challenged by the study. The discrepancies extracted from the tetrahedral model in Fig. 2 imply the changes in the requirement of individual capabilities. What's more, the SCC's hierarchy was structured in a way that "operator as receptionist, supervisor as coordinator, engineer as technical consultant and captain as final decision maker". The organizational issue might deteriorate the time stress when employing incompetent personnel (see Fig. 3). For example, the operator delayed reporting to the supervisor because of over-confidence or he miscommunicated with the captain/engineer when there was engine alarm; the captain involved was completely out of the loop, but supposed to make the final decision. Literally the captain became the team-SA chain's weakest and most vulnerable link when he had difficulty developing SA about situation. What is the difference between the operator's role and captain's role? Where shall the system draw the line between different roles, duties and responsibilities? Are there other possible configurations, role appointments, organizational hierarchies?

Admittedly the project team employed state-of-the-art technology to develop a real-time system for the tests based on an envisaged organizational hierarchy in an "old wine in a new bottle" fashion; the human factor issues imply that the design of the SCC system should not be a mimic of the bridge system onboard. The SCC prototype is a typical application of exceedingly complex distributed automated systems. Considering the gaps from practice, the design of an automated system in remote use should not only organize the technology around the human's needs when they are not “situated”, but also focus on how different parts of system could work as a whole in the context from a genuine system perspective.

5. Conclusions

The discrepancies found in the tetrahedral model adapted from harmony revealed the changes in SA requirements when moving command and control from ship to shore. They corresponded with the gaps that prevented the operator achieving sufficient SA in the existing system. In addition the gap in organizational hierarchy and regulations also hampered the team SA. These findings suggest that on the one hand, in the marine field a hindrance to an operator’s ability to obtain and maintain SA is the geographical separation from the vessel and may be further compounded because of issues related to highly automated environments and inappropriately structured organizational hierarchy; on the other hand they shed light on the human factor knowledge and design principles used for the overall sociotechnical system design in the SCC. The design of the SCC shall not be a mimic of the bridge design. The human factor issues from the current prototype system suggesting aspects on which the design could be improved to be more SA-oriented to enhance remote SA and regain harmony onshore.

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References

[1] T. Porathe, J. Prison, and Y. Man, “Situation awareness in remote control centres for unmanned ships,” in RINA Human Factors in Ship Design and Operation Conference, London, UK, 2014.
[2] M. R. Endsley, “Design and Evaluation for Situation Awareness Enhancement,” Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 32, no. 2, pp. 97-101, October 1, 1988, 1988.
[3] J. Prison, M. Lützhöft, and P. T., “Ship sense - what is it and how does one get it?,” in RINA Human Factors in Ship Design and Operation Conference, London, UK, 2009.
[4] J. Prison, J. Dahlman, and M. Lundh, “Ship sense - striving for harmony in ship manoeuvring,” WMU Journal of Maritime Affairs, vol. 12, pp. 115-127, 2013.
[5] J. Prison, “Ship sense - exploring the constituents of shiphandling,” Institutionen för sjöfart och marin teknik, Maritime Operations, Chalmers tekniska högskola, 2013.
[6] Y. Man, M. Lundh, and T. Porathe, “Seeking harmony in shore-based unmanned ship handling – From the perspective of human factors, what is the difference we need to focus on from being onboard to onshore,” in 5th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences, Krakow, Poland, 2014.
[7] G. Grote, J. Weyer, and N. A. Stanton, “Beyond human-centred automation – concepts for human–machine interaction in multi-layered networks,” Ergonomics, vol. 57, no. 3, pp. 289-294, March 4, 2014.
[8] M. Q. Patton, Qualitative research & evaluation methods, Thousand Oaks Ca.: Sage, 2002.
[9] C. Lewis, and R. Mack, “Learning to use a text processing system: Evidence from thinking aloud protocols,” in Proceedings of the 1982 Conference on Human Factors in Computing Systems, Gaithersburg, Maryland, USA, 1982, pp. 387-392.
[10] J. S. Dumas, and M. C. Salzman, “Usability Assessment Methods,” Reviews of Human Factors and Ergonomics, vol. 2, no. 1, pp. 109-140, April 1, 2006, 2006.
[11] M. R. Endsley, Designing for Situation Awareness: An Approach to User-Centered Design, Second Edition: CRC Press, Inc., 2011.
[12] M. R. Endsley, “Situation Awareness Misconceptions and Misunderstandings,” Journal of Cognitive Engineering and Decision Making, vol. 9, no. 1, pp. 4-32, March 1, 2015.
[13] M. R. Endsley, “Toward a Theory of Situation Awareness in Dynamic-Systems,” Human Factors, vol. 37, no. 1, pp. 32-64, Mar, 1995.
[14] J. Corbin, and A. Strauss, Basics of Qualitative Research 3e: SAGE Publications, Inc, 2008.
[15] U. Kuckartz, Qualitative Text Analysis: A Guide to Methods, Practice and Using Software, London, UK: SAGE Publications Inc, 2014.
[16] M. D. McNeese, E. Salas, and M. Endsley, New trends in cooperative activities: System dynamics in complex environments, Santa Monica, CA: Human Factors and Ergonomics Society Press, 2001.