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THE VALUES OF ERGONOMICS IN SHIP DESIGN AND OPERATION

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SUMMARY

The industry of shipping and ship design involves a set of requirements and business strategies that aim at reliability, efficiency, keeping up with state-of-the-art technology and creating a competitive advantage. Inattention to ergonomics (or human factors) in the process may, however, jeopardize the safety of onboard operations and, in turn, implicate higher costs for the company. Ergonomics and user involvement applied to design through a User-centred Design (UCD) approach is believed to result in several success factors that improve the overall safety and quality of work and life onboard.

This study explores and disseminates the success factors of UCD from which seafarers believe they can benefit as ship users. Such is done by cross-examining data from two focus group interviews comprised predominantly by participants with seagoing experience. The results show that the participants perceive UCD as an added value in terms of physical, cognitive, psychosocial and organizational improvements. Communication between stakeholders, usability, safety and satisfaction are a few of the categories that result from the identified success factors.

This study conveys a comprehensive summary of the success factors collected in the focus groups, of the corresponding categories and of the affected dimensions of life and work onboard. Such findings represent the importance of UCD for those who operate ships and may serve as an incentive for ship-owners and designers to adopt a UCD approach, as well as for researchers to continue studying this subject further.

Key Words: human factors, end-users, user-centred design, user involvement.

NOMENCLATURE

CSE	Cognitive Systems Engineering
HCD	Human-Centred Design
HF	Human Factors
ICS	International Chamber of Shipping
IEA	International Ergonomics Association
IMO	International Maritime Organization
ISO	International Organization for Standardization
JCS	Joint Cognitive Systems
UCD	User-Centred Design
std	Standard deviation

1. INTRODUCTION

Today, maritime transport services represent approximately 90% of world trade, turning the shipping industry into the backbone of current economy [12]. This industry has been developing towards environmental protection [26]; improved cargo-handling systems [26, 29], hull design, propulsion [29], ship structure [15]; and enhanced manoeuvrability [26], with the purpose of achieving increased speed, capacity, reliability [29], efficiency, productivity [15]; and a reduced number of accidents [15]. Simultaneously, ship-owners have had a continuous concern towards the introduction of state-of-the-art technology, the creation of a competitive advantage [26], and the reduction of operational costs through reduced manning levels [23, 26]. Nevertheless, there is still room today for the enhancement of safety, especially associated with the reduction of casualties [6].

It has been estimated that 60-80% of all casualties at sea are the result of operator error and that this costs the maritime industry around $541 million a year [1]. However, operator error is but a symptom [8] and its underlying causes are often found to be related to Human Factors (HF) issues, including the shortcomings of training, communication, procedures and design [1]. Deficient integration of HF in design may in fact translate into poorer operations, higher training costs, and increased risk of failing the task [11]. When appropriately integrated, on the other hand, HF knowledge can lead to better design [8], and facilitate the understanding of practical problems and their solutions [19], helping to improve a large scope of dimensions, such as the habitability of the ship, maintainability, workability, controllability, manoeuvrability, survivability [16], safety, occupational health and emergency response [2, 10], security [2], usability, reliability, supportability, acceptability [3], and affordability [20]. Overall, this is believed to benefit the employee in terms of prerequisites for improved well-being and for doing a better and more effective job, and the employer in terms of improved work performance of individuals and groups in the organization [8].

Even though this conception is supported by numerous authors, others point out the difficulty there has been in HF engineering to put into practice a design-driven approach, seeing that there is a dilemma in keeping a scientific methodology in developmental studies [19]; or the challenges in conveying a usability mind-set [22]. HF integration in design processes in practice seems, thus, to remain limited [19]. Facilities and systems continue to be

designed with little consideration for the humans who interact with the systems [7].

User-centred Design (UCD), or Human-centred Design (HCD) (terms used interchangeably in literature (e.g., [17]), has been promoted by The International Ergonomics Association [13] as the enabler for the application and integration of HF principles, methods and techniques into design (see also ISO 9241-210:2010) [6, 17, 24]. The large array of HF methods can be applied in the different stages of design processes in order to tackle HF issues through a systems approach [24].

By definition, UCD is precisely the process of applying HF knowledge to design. That is, to take into account human capabilities and limitations at each stage of the design process (see Figure 1) [11, 17]. Figure 1 illustrates the five phases within the design process established by the ISO 13407 standard on HCD.

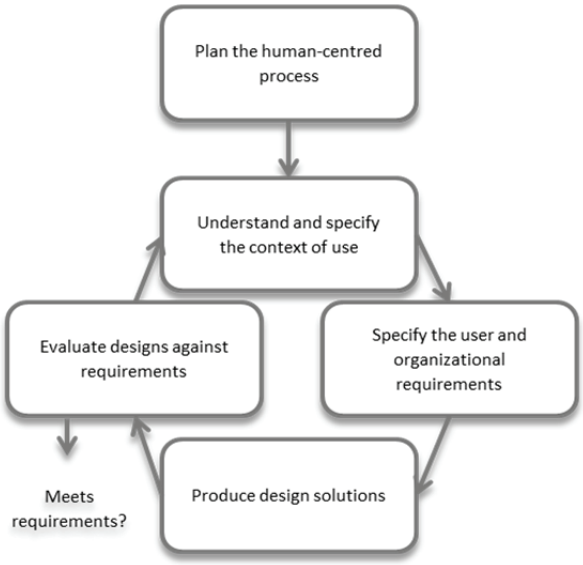

Figure 1: The ISO 13407 standard – HCD cycle (adapted from **[17]**).

The way in which UCD can contribute to the improvement of the work environment is by increasing overall system usability [11, 17]. The ISO 9241-210:2009 [3] documentation about HCD for interactive systems has nominated HCD as the main and universally accepted design-for-usability method and has expressed great concern for usability and quality in use. The ISO 9241-11 defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [27]. Maguire [17] lists increased productivity, reduced errors, reduced training and support, improved acceptance and enhanced reputation as benefits of designing a usable system. A lack of user involvement might implicate the risk that the new tool or interface does not entirely fit the user, the purpose and context of use in actual practice. This can be avoided by applying a series of HF methods that call for the active participation of users in the iterative design process, the thorough analysis of user and task requirements, the appropriate distribution of functions between technology and user, and the input of multiple experts [17].

This study focuses on capturing and analysing the success factors of UCD from which seafarers believe they can benefit as ship users. Considering they perform the onboard operations, they should constitute those who primarily gain from a user-centric design approach as support to their work and enhancement of overall system performance and safety at sea.

It is believed that the systems perspective and HF intervention programmes will gain more and more ground in the future of the maritime domain, together with usability testing and UCD in the development of equipment, due to the growing automation and technological complexity. The expected results are "better, more intuitive, and more fail-safe user interfaces" [8] (p.176). Considering this, it matters to explore the end-users' perceptions of how valuable UCD might be, their motivations for participating of the design processes, as well as what they expect to be able to get in return.

2. METHODOLOGY

This study adopts two main data collection activities: a systematic literature review and two focus group interviews.

The purpose of focus groups 1 and 2 was to find out what seafarers perceive as benefits of a UCD approach when applied to their workplace. Both sessions were planned in regards to the topic, time, place, tasks, moderators, needed equipment, refreshments and participants. They were held in a controlled and structured manner, led by the main moderator, in a room with the appropriate conditions and tools. An assistant moderator was present, took comprehensive notes; operated the recording devices; handled the various hand-outs; provided with refreshments; and intervened in the discussion occasionally with a few probes when appropriate [15, 21]. The sessions were recorded with the help of multimedia devices with the suitable written consent of each participant. A form was also handed out to each participant as to collect some of their demographic details.

2.1 FOCUS GROUP 1

2.1 (a) Sample

This focus group took place within a workshop associated with UCD issues in the maritime domain, sponsored by the Nautical Institute. The participants were gathered for the workshop.

Considering that focus group members are meant to have something in common that links them together and to the topic [21], people who had confirmed their presence at the workshop and who had seafaring experience in common were contacted in order to also confirm participation in the focus group. Eight participants with seagoing experience had confirmed their participation. However, due to the focus group being held within a workshop with a larger number of attendants, the mentioned eight participants plus three extra persons ended up taking part in the focus group. Thus, the first focus group consisted of a total of 11 male participants, among whom 2 still active in seafaring jobs; 8 were no longer performing seafaring jobs (50% of which were working in different activities, and another 50% were retired); and only 1 who had never had any experience at sea. All of the participants were of Scandinavian nationalities, except for one who was from Western Asia. They were between 40-71 years old, with a mean age of roughly 56 years (*std* = 12.2).

2.1 (b) Procedure

Before the research question was introduced, a very brief definition of the concept of UCD was presented (in a manner that would intentionally try to avoid any priming) in order to provide everyone with the same basic understanding of the topic. Afterwards, the following research question was presented:

Considering your experience working and living on ships, and the previous briefing, what do you perceive are the benefits of applying User-Centred Design to ships?

Succeeding this question, each participant was asked to think and write individually a list of UCD benefits for the seafarers that they could think of. They were given approximately 10 minutes for this activity and then moved on to a group discussion. While they were revealing the various benefits, the main moderator was moderating the discussion as well as introducing follow-up questions and creating a mind map on the whiteboard, separating benefits in different categories. The group discussion took about 50 minutes, followed by a coffee break. The final part of the focus group was shorter than planned, considering that some of the participants needed to leave earlier for personal reasons. This second part consisted in individually picking one or two benefits that they considered the most important of all for the seafarers, and there was not enough time left to discuss further. Overall, the focus group took one and a half hours, which is within the amount of time suggested in the literature [15, 21].

At the end of the session, the participants received a participation certificate as a token of appreciation on the researchers' behalf.

2.2 FOCUS GROUP 2

2.2 (a) Sample

A convenience sample of 10 Swedish university students was invited to participate in this focus group. The students' backgrounds were considered prior to selection: they were studying the same academic programme to become master mariners and had between 6-50 months of experience at sea, being that the mean was 14,5 (*std* = 12.6) months and the mode 11 months. The participant with the most time spent at sea had been involved in interface design before, and the remainder had never had any connection to design. 70% of the participants were male and 30% female, with ages between 22 and 32, a mean age of 25 years (*std* = 3.7) and a mode of 22 years.

2.2 (b) Procedure

The participants were directed towards discussing the various "success factors" that would correspond to the benefits of UCD:

Identify success factors of user involvement in the design process of the work environment onboard.

The problem presented above had the same aim as the previous focus group but was however posed in this manner to try to have the participants relate to the question as seafarers and not as UCD experts; this way avoiding any ambiguity regarding the concept of UCD.

Firstly, the success factors were listed on the whiteboard freely and creatively, as the participants would simultaneously explain why they felt a given factor was a success factor for them. Afterwards, redundancies were removed from the board as to be able to prioritize the 10 most important factors to them. Then, they were asked about the extent to which each of the prioritized success factors exist in reality today (*can you find them easily?* to *can you find them at all?*).

3. DATA ANALYSIS

After the data collection, the audio-recordings were transcribed and analysed together with the field notes and pictures of the mind map created on the whiteboard during the sessions. A cross-analysis of both groups was posteriorly done with the support of Grounded Theory [5]. The Grounded Theory method is an inductive, comparative methodology of analysing raw qualitative data. Its approach is based on a set of coding procedures to provide some standardization and rigor to the analysis. Its purpose is to develop, generate and create new theory and concepts about the social world rather than to test existing ones [21, 25].

Table 1: Benefits of UCD for seafarers

Benefits/ Success Factors	Categories	HF Dimensions
• Having the user in focus • Availability of information • Better design implies it is more difficult to make mistakes • Attending to context of use: different users/different ships; making equipment easier to work with during day and night time • Avoiding complicated solutions • Creating more intuitive systems (in the sense that they are easy to understand and use, and not much time needs to be put into it just to be able to work with it) • Considering cognitive versus physical logic (*"when tightening, you pull the handle towards you; when you tighten with the remote control, you push it away from you, and that's bad logic"*) • Making systems more user-friendly: systems shaped for the users and not the other way around; considering physical ergonomics, easily accessible information, less unimportant information, easy menus; easy to navigate the system, easy to find; adapted to the purpose (*"mission-specific"*); variable systems that can adapt to the individual (*"not static!"*) • Improving ergonomics in terms of vision, reach, lift • "Making the bridge design more user-centred": accessibility of the console for the ones who are meant to use it (*"the second mate has to stretch to reach the VHF"*); controls on the armrest; cup holders • Making space to carry things around, with no hazards in the way (pipes, ceilings, gaps, steps) • Positioning screens and buttons properly for reducing running around and useless motions • Designing fool-proof equipment (impervious to human error) • Better teamwork in a more user-friendly environment	Physical Ergonomics & Usability (hardware and software)	Workability: consideration put into users, tasks, equipment, procedures, work environment, information and language [16]
• Reducing repetition of parameters on the screens to where they are absolutely relevant and necessary (conning display, radars…) in order not to distract the user from vital tasks – create the bridge systems in an integrated manner • Improving efficiency of system usage: less complicated, information more accessible, avoiding having to read the manual, time saving, easy to use, flexible for the user to rearrange menus, better situation awareness	Efficiency	

• Making procedures standard on all ships for avoiding mismatches and mistakes • Taking measures regarding cargo-handling and vessels serving other purposes they were not intended for, which can make seafarers' lives riskier and operations more complicated • Deciding on available hours for the seafarers, to allow them to rest fully when off-duty (*"today seafarers often have to be available at all times"*)	Job/task/procedures/routines	
• Harmonizing training across cultures • User-centred training design: how to teach students in the best way; confront them with real user interfaces and not just simulators	Training	
• Harmonization of bridge equipment (since there are different manufacturers for different pieces of equipment on the same bridge, there can be certain incongruences) • Standardizing hardware and software and allowing for individualized profiles would support familiarity, time saving, avoidance of misunderstandings, less time changing watch • Standardizing training, procedures and lifeboats	Harmonization/ standardization	
• Adaptable equipment: multifunction display/mode switching (docking, etc.) and multifunction input for a flexible use (*"not all parameters on the screen are important at all times"*) • Creating variable systems that can adapt to the individual (*"not static!"*) through individual profiles and menu flexibility	Variability/ flexibility	
• Having comfortable and user-friendly common areas (chairs, cup holders, recreational spaces, stairways, accommodation)	Physical Ergonomics & Usability (hardware and software)	Habitability: Adequate and comfortable accommodation and recreational spaces having regards for size, shape, gender, culture of the seafarer and environmental stressors such as noise, temperature and vibration. [16]
• Improved social environment onboard in leisure time	Social environment	
• Accounting for diversity: different people like different things; individualization in the leisure areas	Variability/ flexibility	
• Creating changeable systems and hardware: arranging space for change and new technology in the systems considering the lifecycle of the ship (instead of adding a lot of new hardware, make the existing hardware adaptable to change)	Variability/ flexibility	Maintainability: Considering access, tools, through-life support for the lifespan of the ship, and designing operational maintenance tasks to be fast, safe, and efficient. [16]

• Safety improvements • Fewer hazards: reduction of number of accidents, injuries, slips, trips and falls • Standardize lifeboats and safety procedures	Safety	Survivability: Adequate equipment and facilities for firefighting, damage control and lifesaving, to ensure safety of crew and passengers. [16]
• Learnability • Creating more intuitive systems • Considering cognitive versus physical logic • Making systems more user-friendly • Improving ergonomics in terms of vision, reach, lift • "Making the bridge design more user-centred" • Making space to carry things around, with no hazards in the way (pipes, ceilings, gaps, steps) • Positioning screens and buttons properly for reducing running around and useless motions	Physical Ergonomics & Usability (hardware and software)	Controllability: Integrating users with equipment and interfaces, and appropriating layout of work stations, communication facilities, controls, displays, alarms, lights, etc. [16]
• Standardizing hardware and software and allowing for individualized profiles would support familiarity, time saving, avoidance of misunderstandings, less time changing watch	Harmonization/ standardization	
• Adaptable equipment • Creating variable systems that can adapt to the individual (*"not static!"*) through individual profiles and menu flexibility	Variability/ flexibility	
• Involvement in ship design enhances motivation and improves the work environment • Motivation	User involvement	Communication and User Empowerment The objective of UCD is to capture users' real needs by cultivating open communication between them and the design team, and the end result is empowered and motivated users.
• Communication between stakeholders: users, ship-owners and designers, in order to fill in the gap between different requirements	Communication between stakeholders	[18]

• Better design can prevent human error, which in turn protects the reputation of the seafarer • Skill development	Career development and reputation	Professional and Psychosocial aspects
• Lower stress • Motivation • "Happy crew"	Satisfaction	
• Reduction of accidents for reduction of costs • Better economy: if the design is done correctly from the start, there is no need to redo, and that's better for everybody – spending the money on the right place and time • Prevention of lay days: lay days cost money if seafarers make mistakes • Less stress leads to less money spent on sick leave • Less training costs needed if systems are more intuitive • Lower costs for relocation of hardware if it is built properly from the start	Economy	Affordability: Refers to the total ownership costs associated with system/technology redesign, manpower, training, human support, and reduction of errors and accidents. [20]
• Better public image and reputation for the company	Corporate image	

4. RESULTS

As a result of the cross-analysis of the focus groups, the following table was generated (Table 1). Looking at Table 1, one can find that the benefits of UCD were put together by seeking opinion of several end-users and professionals of the maritime industry, and linked to HF dimensions mentioned earlier in this paper, which represent the typical HF considerations when speaking of ship design. This table is hence organized with (1) the various benefits/success factors mentioned by the participants, (2) the concepts that categorize the sets of benefits, and (3) the HF dimensions which they ultimately affect (e.g., the workability in the ship will increase once physical ergonomics and usability are improved through features such as screen displays that adapt to the context of day and night use, bridge systems that are more intuitive, etc.).

Note that some benefits and categories are repeated in the table; yet, for example, the category of *Psychical ergonomics & Usability* that affects Workability does not comprise exactly the same list of benefits as the one that affects Controllability. This means that the categories are quite broad and can improve various dimensions at once, but in somewhat different manners.

In the ranking task, the participants in focus group 1 seemed to agree that the best selling point of UCD is safety. Focus group 2, on the other hand, began to create connections between the different benefits in order to help them make a decision. They mentioned that many of the benefits were results of others, which made their decision somewhat difficult. The benefits are linked rather than isolated. Finally, they considered that filling in the gap between end-users' needs and ship-owners' requirements was the most important benefit of user involvement in the design process. Once the communication between ship-owner, designer and user is facilitated through UCD, "*a foundation is built for all the other success factors that follow. The important thing first is to allow communication between ship-owners and end-users*". The participants proposed focus groups, paper mock-ups, interviews and simulators as means to allow for proper user input. Maguire [17] claims that these aids are essential to the support of the iterative design lifecycle and better applied in the initial stages, being that it is more economical to make the suitable changes according to user feedback earlier rather than later.

5. DISCUSSION

5.1 METHODOLOGICAL DISCUSSION

The intent of examining the body of literature by using a snowball strategy was to search for (a) previous studies on the topic of benefits of UCD in general and (b) within the maritime domain, specifically for seafarers as the group of end-users. This allowed a deeper understanding of the concept and the identification of key-issues.

The focus group interviews facilitated the understanding of certain perceptions and reflections of a problem that might not have been accessible outside of a group dynamics [25]. Bloor, Frankland, Thomas and Robson [4] state that focus groups can provide access to group meanings, processes and norms behind collective views or group assessments. Another advantage of this qualitative method is ascertaining whether there are consistent or divergent opinions in a common group on a given topic, in a short period of time [21]. Nevertheless, comparably to other methods, focus group interviews have their limitations. For example, researchers using this method must take into account that people might not say exactly what they think or how they feel in the context of a group, as they would if they were alone with the interviewer [25]. Focus group interviews might also incite a false consensus during the group discussions for avoiding possible conflicts [25]. Moreover, the fact that the focus group interviews were being audio-recorded in this case might have restricted the behaviour of the participants to some extent [15]. Nonetheless, focus groups were an appropriate method for this topic, because the participants could make associations and reflect on things they would have not come up with on their own. The influence they have on one another and the disagreements and exchange of ideas and opinions produces richer conclusions than the individual parts [17].

Besides these general limitations, the majority of participants in the first focus group were middle aged and had many years of seafaring experience, perhaps not similar to the fresher experiences of younger seafarers. Especially for those who were already retired, their opinions might not entirely apply to the shipping industry of today. On the other hand, they may have a superior view of how the industry works, how stakeholders relate to each other; of what is possible and what is important.

There were also participants in the first focus group that did not belong to the cluster of seafarers, even if they had relevant experience in regards to other professions in the maritime sector. For such reasons, a second focus group interview with students was held in order to put together a larger range of benefits assembling a variety of experiences. The groups were, however, not posed the problem equally, even though the objective was identical. The question for the first focus group may have been more ambiguous and prone to causing priming than the second, due to the mentioning of the concept of UCD to a group of participants who were not UCD experts but participated in a related workshop prior to the focus group session precisely because of their interest in learning about shaping ships for the users. Trying to tackle ambiguity and possible confusion derived from the workshop discussions, a very short and basic definition of UCD was given before the discussion to generate a

common understanding of what the researchers wanted to discuss, but trying not to prime their answers as to what the benefits of this approach may be.

The second focus group was expected to identify themselves more with the manner in which the research question was posed, seeing that it was asked in a more concrete way, replacing 'UCD' with 'user involvement'. They had difficulty, though, ranking the most important benefits on account that they were so interrelated and interdependent.

There cannot be certainty of how much the sum of participants knew of UCD before their input in the focus group sessions, especially considering that most of them in focus group 1 took some part in naval design at some point of their professional careers, and the participants in focus group 2 had been receiving academic education in HF contents, even though UCD had not yet been focused on. So it is discussed here that these groups might have been primed with influencing ideas regarding UCD prior to the focus group sessions. That is, they might have been lead to some extent to give the answers they gave.

Both sessions were limited in terms of time and it was not enough to confirm the different categories with the participants – especially focus group 1 that ended earlier than predicted for personal reasons of the participants. This might have affected the results to some extent. Nonetheless, during the data analysis, categories and HF dimensions were established according to literature in the matter.

The data analysis method was chosen for being a solid, objective but creative framework for the analysis of qualitative research, and has been the most prominent in the field of social sciences [21]. The use of this method helped find the common denominators within and between groups, reduce them to categories and link the latter to existing theoretical HF dimensions, and expand the understanding of how seafarers can benefit from a UCD approach.

5.2 RESULT DISCUSSION

The results show that the participants perceive UCD as an added-value in terms of physical cognitive, psychosocial and organizational improvements.

Focus group 1 had more seafaring experience than focus group 2 in general and they were also able to identify more varied benefits of UCD. It was focus group 2 who suggested, however, that there may be downsides to user involvement, which could very well be a good topic for future research.

The variation of the participants' backgrounds in regards to types of ships, time at sea, etc., contributes to this study in the sense that more opinions may have been collected from a seafarers' perspective. The idea is that UCD focuses on the user and the context of use, but even if the context of use is specific to a section of the vessel, a type of ship, a system, a tool or a task, it must be generally usable to all types of seafarers. Crews today are considerably diverse and swap ships frequently, so it is difficult to determine who will work where. Therefore, design must account for every possible user.

Österman, Rose and Osvalder [30] identified various factors as being of utter importance for the achievement of a good work environment and safety onboard. These were related to organizational factors more than to physical or cognitive ergonomics, such as employee participation, which is believed to elevate crew morale and make the crew feel heard; it can improve business operations and even influence purchasing processes. For these reasons, the authors suggest it should become part of the organizational culture. This suggests a change in the values and attitudes of stakeholders, and requires communication among them; a compromise.

As the transcriptions were made and the results analysed, it became clear that there was a common tendency for the groups not only to count in the direct benefits for the seafarers but also certain benefits for the ship-owners, which ultimately have positive effects for the seafarers themselves, such as reduction of costs in the sense of spending the money on the right thing and in the right time. It was in fact agreed during both sessions that most success factors can translate into drivers for the ship-owners to invest in HF, considering that they would benefit from the reduction of accidents and costs, and from a more efficient crew. It rests on the ship-owners to act in the same direction. What is more, the improvement of the work environment onboard through HF may as well enhance organizational learning and the attractiveness of the business. In turn, the latter may help retain competent personnel and help create competitive strength in the company [3, 30, 31] by highlighting its corporate image [9].

The implementation of HF can equally contribute to sustainability, seeing that its principles account for user needs and the interactions of humans and systems through a systemic perspective [28]. HF can, then, ultimately contribute to safe, efficient and sustainable sea transport [31].

According to Grech, Horberry and Koester [8], a way to view human factors applied to ship design and operation is to consider them from three contextual levels: the context of the person, the job, and the organization and management. Both groups mentioned procedures and job design, the contexts of use and the personal differences within the crews. The first focus group also mentioned training from a UCD point of view, in the sense that it must be thought of in a manner that harmonizes training across different cultures for the purpose of having standardized procedures and jargon when multi-cultural crews work together. This being said, standardization

was truly enhanced throughout the sessions as a path to efficiency and safety.

As a final note, both groups proposed a few considerations to be taken into account in the course of the UCD process itself, notably that it does not suffice to involve senior officers in design. Younger officers may give essential input in usability testing as well, bearing in mind their technological experience and vision. Able seamen (AB) and other technicians must equally participate in design processes for their respective departments onboard. The participants also recommended (a) that users take part in the development of IMO regulations and in ship purchases, to ascertain that these are in tune with the users' needs, as well as (b) that HF specialists support the processes to discern what users need and what they want.

6. CONCLUSIONS

The findings in this paper contribute with a broad view of UCD success factors in the perspective of real-life maritime users and show the relationships between the different categories and the HF considerations that they help improve. Said findings represent the meanings of UCD to those who operate ships and may serve as an incentive to ship-owners and designers to adopt a UCD approach, as well as to researchers to continue studying this subject further. Moreover, it raises awareness of the importance of considering the user as an integrated part of a much larger system. Enhanced safety cannot emerge from solely blaming users for committing errors, but from evaluating the causes of them and proactively looking for solutions that will avoid the reoccurrence of the problems.

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