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INTERACTION DESIGN IN SHIP BUILDING: AN INVESTIGATION INTO THE INTEGRATION OF THE USER PERSPECTIVE INTO SHIP BRIDGE DESIGN

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Abstract:

This study investigates into the involvement of the user in the design process of ship bridges and navigational equipment as seen from the designers' perspective. Following a qualitative approach, designers were asked about their work habits and guidelines. Four different images of the navigator were identified, ranging from "servant to the engineering" to "power- and skilful bridge manager". These types evolved from surprisingly different notions on topics such as basics of ergonomic design, human factors and usability, feedback loops in design, and system knowledge of the user. While there was a general interest in usability, interaction design and human factors among designers, there was also evidently a lack of detailed, concrete knowledge. This leads to the conclusion that there are still a number of difficulties with respect to organizational structures and internal as well as external collaboration that hamper integration design. Some possible solutions to these problems are discussed.

Keywords: design study; ship bridge design; user participation; human factors; design practice.

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INTRODUCTION

The bridge of a modern ship is a highly complex system. This is not only true with respect to the nautical technology, but also with respect to the multitude of interactions between humans and technical systems that are required for safe navigation. We therefore can speak of a socio-technical system, a tightly knit network of modern technology and a host of human factors as well as prerequisites of interplay between these aspects.

Obviously, this interaction between humans and different soft- and hardware components offers numerous possibilities for difficulties. As in other complex and safety-related industries, it is practically impossible for the developers of technical ship bridge components to foresee all conceivable risks and hazards and minimize their likelihood through appropriate design features. But even if this were possible, nautical officers would still be "naturally vulnerable to designers designing in a way that impedes operators' reasonable intentions" (Busby and Hibberd, 2002 pp. 132-8).

It is therefore important that the process of developing technical devices and systems that are supposed to assist humans in such complex tasks be conducted in close exchange with the end-users of these developments (see Herczeg, 2005; Transportation Research Board, 2003; Scolari, 2001). When, some 25 years back, Gould and Lewis (1983, 1985) formulated their now often-cited principles for interface design, they put "early focus on users" at the top of their list. In everyday life, however, user involvement still often lies somewhere between "rare" and "absent" (see King, 1995) and "developers are therefore forced to, design in the dark' ", as Nandhakumar and Jones (1997) describe the problem.

Given the risks involved, ship bridges should be organized and designed in way that offers maximum safety and efficiency – not only under normal circumstances but also under conditions of rough seas, in emergencies, and during operation by stressed, fatigued, or overloaded mariners. If these aspects are ignored, work on a ship bridge would fall prey to the same observation Busby and Hibberd (2002, pp. 132-8) formulated as a result of their study on the misunderstandings between designers and users: "An important causal factor in many failures of complex engineered systems and the subsequent accident sequences is a mismatch between the intentions of the system designers and operators". To counter this mismatch it is critical that the design of complex systems is not only driven by the latest advances in technology. The user and his necessities under different working conditions require the same amount of attention as do the general principles of human information processing and action regulation. These are often subsumed under the label "human factors", meaning those special principles that determine human behaviour in dealing with complex sociotechnical systems (see, e.g., Cherns, 1976; Dörner, 1989, 1999; Hawkins, 1987; Reason, 1990; Vicente, 2004).

The integration of this claim into the design process has gained different levels of momentum in different industries. The merchant marine is most probably not among those leading the pack. Even the most modern ship bridges cannot deny their evolutionary past as they are still quite reminiscent of 19th century technology. Improvements in safety and efficiency are still mostly sought through purely technological solutions without proper recognition of the systemic character of the task of sailing a ship (Lützhöft, 2004; Lützhöft & Dekker, 2002). To avoid the problems other industries have encountered following this "technology philosophy" (see Dekker, 2005, for the example of civil aviation), new developments in ship bridge design require the integration of the views of the users (the nautical officers), the ship builders, the bridge designers, the hard- and software engineers, and human factor specialists.

This article reports some of the results of an interview study that was conducted as part of just such a collaborative project in ship bridge design. We made inquiries into the user models that are entertained by designers of ship bridge systems and we asked them about the ways in which the user perspective is integrated into the engineering process as well as the human factors knowledge they can use in the design process. From this material we could isolate some tendencies which in our opinion are not restricted to design for the merchant marine. They might also be valid for other industries that are not especially "high risk" but are still characterized by complex man-machine-interactions. This article, then, is also an attempt to intensify the debate on how communication between different stake holders in such developmental processes can be improved (see Dekker & Nyce, 2004).

BASIC PRINCIPLES IN USABILITY

Human factors research in the maritime area is still relatively rare (see Adams, 2006). However, human factors research in other operational fields which are similarly complex has revealed several conditions that a well-designed man-machine interface should meet (see. e.g., Herczeg, 2006; Mearns, Flin & O'Connor, 2001):

— *Situational Awareness*: The interface is designed in a way that makes it possible for the operator to generate (and constantly update) a complete and process-oriented overview of everything that is relevant for his ship.

— *Shared Mental Model*: The display patterns, the mode of presentation, and the handling of displays, software tools and manual controls support different operators in constructing a coherent, shared, and correct picture of the situation.

— *Development of scenarios:* The presentation of information is designed in a way that assists operators in the quick identification of developmental patterns (e.g., course information from other ships) thus enabling them to form an "expectation horizon" of what is going to happen in the future and construct different developmental scenarios.

— *Standardization and functionality*: With respect to information presentation and functionality, interfaces are standardized to an extent that allows operators to orient themselves quickly. The basic laws of ergonomics need to be taken into account, elementary components need to follow the same construction principles and all display-control-loops should follow the intuitive action patterns of the watchkeepers.

— *System understanding*: All systems on the bridge should be designed in a way that the nautical officer is able to easily understand and review the relationships and interactions between their different components. Only then is it possible to identify and control the consequences of a malfunction or component breakdown.

THE INTERVIEW STUDY

As mentioned above, we were interested (a) in learning about the ways in which the principles of ‚Interaction Design' are already safely anchored among those that are involved with the development of integrated ship guidance systems and (b) in investigating the human-factors principles that are considered and incorporated during the design process. We therefore conducted an interview study with engineers, designers and process supervisors from different nautical developmental units[1]. All in all, 13 men and one woman participated in the study. Seven interviewees were working in development departments of companies building advanced ship guidance systems such as radar, ECDIS (electronic chart display and information systems), or AIS (Automatic identification system). The remaining seven came from ship yards, either working as ship constructors, construction supervisors or yard captains, the latter both as test runners and construction advisors. All companies are located in Germany.

The interview process was designed to shed light on the complete design process – from the initial idea for a new device or bridge component to its final implementation. Special attention was paid to the question of how far and in what ways the developmental process was influenced by the concerns of the users and to the possible human factors-compatibility of the resulting man-machine interfaces. The interview scheme consisted of several pages and covered the topics we present in the results section.

The interviews themselves were conducted along the lines of an anthropological-observational research approach (see Hutchins, 1995). Here, the interview partner is considered the expert in the field and the interviewer takes a chary role of asking and observing. Accordingly, the interviewers left plenty of space for the personal experiences and opinions of the designers. All precautions were taken to establish an open atmosphere and not to influence the experts in any respect. The interviews last-

[1] For the sake of readibility we use the term "designer" throughout this paper.

ed between one and three hours and were conducted by well-trained psychologists who had earlier collected informal observational experiences sailing on the bridges of different vessels.

The interviews were tape recorded and later transcribed. All interviews were conducted in the German language; the translations for this article were prepared by the authors. In analyzing the transcripts we quickly found that the answers given and the stories told were far too diverse to be condensed into any narrow categorical system. Nevertheless, the interviews yielded a number of interesting insights. In the remainder of this article, we will discuss this material following the logic of qualitative research. We will therefore try to condense our interview partners' statements into the main propositions and illustrate these by quotes. The order of the presentation follows the different topics that allow us to sketch a complete, yet diverse picture of the current status of the integration of human-factor principles and interaction design into contemporary ship bridge design at least in some parts of Europe.

RESULTS

Many voices – many perspectives

A general feature of the results is the considerable variance in the statements and ideas of the experts (c.f. Sheridan, 2003). While some interviewees focussed their position on technological developments (to which the user must adapt), there are also representatives of the counter position who argue that it is necessary to base one's thinking on equipment and its improvement on the mariner and the conditions of his work. This range is exemplified in statements like "We try to produce a device that does everything by itself so that manual inputs are only the last resort" versus "One often sees people relying on technology without switching on their own head. I see this as a big danger".

Thus, the appraisal of the interaction between user and technical systems depends on the interview partner. Even with designers coming from the same company we found very diverse perspectives. This somewhat surprising observation indicates that user models might not be part of the corporate philosophy. One reason for this diversity could be the host of norms and regulations that determine forms, features, and functionalities of many details in ship design. Many designers complained about this over-regulation which limits possible solutions and hampers creativity: "Everything is predefined on a very detailed level outlining what we may or may not do"; "We develop new instruments if we need to fulfil new rules or specifications or if they need to be redesigned due to technology changes" – and even in the latter case, design work is limited by specifications in connection with compatibility requirements. One of the problems with all these norms is the lack of explanation of the ergonomic necessities behind them. The origin of the norms they have to adhere to is unclear to many designers: "I assume they're very old… I don't know what the origins are". Thus, each designer tries to find his individual way through this maze of norms, regulations, and specifications. Ergonomical considerations as well as the user perspective surface only temporarily: "To look into ergonomical issues gets relevant only batch-wise, depending on the thrust of new technological developments and regulations".

Guiding a ship: Craft or complex task?

In analyzing the interviews it becomes clear that there are highly divergent preconceptions about the user, in this case the mariner. We grouped them into four user models which represent a sort of typology of the designers' images of the users they design systems for. We briefly characterize these models and illustrate them with quotes made by designers during the interviews:

Technical Administrator

Basically, the user is seen as operator and administrator of the bridge systems. All important functions and tasks are autonomously dealt with and controlled by technical devices.

"From here to there… then he can fall asleep": Since everything else is taken care of by the automatic route planning system, it is sufficient to have one person on watch on the bridge.

"The navigator on a ship is no longer a navigator but only an email-receiver" who follows the "orders" of the ship owners. They are better able to control things from a distance.

Coordinator

The user primarily coordinates technical systems. He supervises their functions and adjusts these in accordance to the nautical situation and task at hand.

The main task is "to bring the steamer from A to B. Secondary tasks are saving fuel, saving time, avoiding bad weather, no collisions, no groundings, staying on course". In general, with respect to navigation, the user is relieved of many things but has been burdened with many side tasks that distract him from his primary nautical tasks.

"I can well imagine that it would be fun to deal with all these technical devices". (Note: This quote is especially interesting because it indicates that bridge systems are designed according to principles engineers and not necessarily mariners can find exciting or challenging.)

Integration Agent

Here the navigator is basically seen as the active user of technical systems. That is, he makes decisions and acts on the basis of an overall picture of the situation which he generates from the available information and technical support systems.

"Navigation is the use of tools which can be learned. The important aspects lie in how virtuosic somebody uses them and thus controls the ship guidance process as a whole".

The navigator "should be relieved in critical situations. In principle, it's the critical situation that counts. If everything comes together - then the technical systems should serve a support function".

Bridge Manager

The user is seen as an autonomous decision maker who uses bridge systems at his discretion if and only if they appear to be helpful for the generation of information, for filtering functions, as backup-devices, or for any other purpose.

"The navigator wants failure-free equipment which reduces his workload and his personal strain so as to give him freedom for the 'big issues'".

"Nowadays, ships can no longer be understood by pure feeling. Technical systems support the generation and maintenance of an overview".

As can be seen from the quotes, designers' user models differ very much with respect to the relationship between bridge systems and navigators. While some see the navigator as a controller and judge bridge equipment basically to be support systems, others feel their technical systems guide the ship and reduce the navigator's role to that of a bystander. This difference, of course, has far reaching consequences for the specification of devices and the question of what is considered "good design". In any case, however, ergonomic principles should be applied to the design of displays, software structures, and controls.

Ergonomics: Cumbersume duty or internalized quality pretension?

In all the interviews considerable time was spent discussing the question of ergonomic principles used in designing bridges and bridge equipment. We again found that the importance attached to *usability* varied between the companies to a considerable extent.

One designer spontaneously described the gap between technological euphoria and the simplicity demanded by the practitioners: "You want an honest answer? It's a nightmare for every engineer to have to deal with a device that has a user interface. This results from the fact that the functions lying behind it are in a black box – there, nobody can piffle. But from the moment when one can look at it, when one can press buttons, the engineer's fears increase dramatically that many people – regardless of whether they were asked for their opinion or not – want to join the discussion. At some time or another every display goes through these processes which are extremely cumbersome for the engineers". Here, it's the pure world of engineering that is contrasted with the cacophoneous voices of customers and users. Under such a perspective it is not unlikely that the "cumbersome" process of integrating user opinions is abbreviated as much as possible.

But even this designer, like most others, thinks that usability enjoys a high priority within his department since "everybody wants to build a nice good device". In his opinion, it is mainly the task of the management to securely anchor this thought in the process of designing but, at the same time, it is part of the engineer's self image: "one certainly tries to put one's heart and soul into the work in order to make it reasonable". And besides, "there are certain class norms relevant, and therefore this is also important".

Contrasting with this philosophical position is the vacuum that is apparent when designers were asked about their ergonomic basics, knowledge sources, or education. In most cases the answers vaguely refers to "experience" or the many regulatory requirements. Their origin, however, remains unclear: "Maybe we have a book, but I wouldn't know where it is".

The significance of usability lies more with the general claim than with its concrete realization. As one interviewee put it: "We don't have our own ergonomists". Sometimes they would ask for external counselling, sometimes an industrial designer "would have a look at it" – but there was no procedure for this. Another designer explains that they would try to implement the same input philosophy with all pieces of equipment that belong to one family and thus coordinate the devices. Basically, however, all important aspects were fixed in the regulations they had to observe. Still another engineer describes that in his field more important developments were made in the context of research projects with external institutes as partners which would then take care of the ergonomic part. There is no use made of domestic data, studies or literature regarding ergonomic topics.

The main problem in implementing ergonomic principles is the lack of background information for the designers. They often have no idea about the rationale underlying a specific ergonomic requirement, so it would be most helpful for the acceptance of ergonomics in design if there was more of this background knowledge available. Or, as one interviewee summarized, "One has to tell people why the things, one expects from them are necessary and what the background is. Otherwise they get frustrated" and the tendency "to wipe it off the table" increases rapidly.

Apart from this rather general treatment of ergonomics in design we also tried to discuss the more specific topic of "cognitive ergonomics" with our interview partners. We asked them about their judgement of the mental skills required for operating nautical devices; we wanted to know what sort of "cognitive endowment" was demanded from the user by the bridge components developed in their departments.

This is, of course, one of the hot topics of usability and it was therefore surprising to learn that there was no detailed knowledge nor were there specific opinions. Rather, the answers were quite general in scope and sometimes quite candid in tone: "The cognitive requirements a navigator has to meet on a modern bridge are rather moderate. In principle, everything repeats itself all the time. To formulate it heretically: If you would ask this question with a ship's Chief Engineer listening – he would laugh himself to death. […] He says, this little bit of navigation, come on, I can almost also handle".

If one takes a closer look at this "little bit of navigation" however, it becomes clear that it comprises highly complex processes of information processing, decision making, goal formation, and monitoring which are altogether functions of working memory (see Anderson, 1993; Kersandt, 2005). Therefore, these processes share the same limited resource and thus have to be balanced via reflection on one's own actions (Kanfer & Ackerman, 1989). As even this quick glance demonstrates, control of a complex system such as a ship's bridge relies heavily on the cognitive conditions of the user and should, therefore, be an issue for the designers.

Only three of our interview partners (after initially admitting that "this is a question one never really thought about") went into a discussion of this topic. This finally resulted in at least some ideas of designers' preconceptions of the cognitive demands to be met by navigators: "A ship is not a car. If I try to steer this ship there is an enormous lead time. One has to know that some things happen only in the future and this is very difficult. A captain, if he steers the ship manually, has to know this". Additionally, the reaction features of ships are quite different and adjusting to another ship requires "mental flexibility".

Another interviewee: "I can imagine that this still requires quite a lot. Because there is a great deal of information one has to receive, overview and process at the same time". "He (the navigator) must be able to work with full concentration. He has to be a person with good powers of deduction insofar as he must be able to say this alarm is not so important at the moment. He must be able to set priorities. And then he must be able to make clear, important decisions. Nowadays, he must be able to deal generally with modern engineering and communication devices. Also, he should be a practical person, able to quickly find out how to fix an error. He should master the English language. The navigator should have a human grasp of the other, a sense of collectivity, especially in dangerous situations".

As interesting and multifaceted as this is, the impression remains that many insights and theories of cognitive ergonomics and human factors research (e.g., the influence of the time of day on control and monitoring tasks, the negative consequences of background noise and informational overload, the benefits of multichannel information presentation, utilizing human strengths in pattern matching and pattern detection; see Cook, Read & Wilson, 2001, Sanders & McCormick, 1992; Vicente, 2004) do not belong to the actively-available knowledge repertoire of the interviewees.

Typical dead ends and the feedback-trap

Another question dealt with the typical dead ends one can stumble into while developing bridge equipment. Some designers actually described problems that resulted from insufficient integration of the user into the design process: “Sometimes you think you’ve done something really beautiful and then the navigator has even better ideas – that’s something you have to recognize”. Yet, most prominent among the dead ends is the problem of functional overload. Everything is too much and too complicated, however, “in 30 years of work in this company the main point of criticism, reduction of functionalities, has never worked”. This problem may be a result of the rapid technological progress during the last decades. As Poltrock and Grudin (1994, pp 52-80) conclude from their study in the problems in Interface Design: “Computational power permits more media to be combined in more ways, and on the other side of the interface, the nature of user populations is changing just as rapidly. Finding an appropriate fit is a challenge”.

One designer talks about the problem of reducing functions to simple logic and simple handling in a self-critical and reflexive manner: “There is a certain arrogance that develops over time: The developer is convinced of something, he says he has checked this thoroughly … and the others just don’t understand it, they ought to read the manual, that’s it. This then results in technical systems being more and more difficult to operate”.

Yet, the existence of systematic feedback loops which would engage designers and practitioners was never mentioned. In some instances, the training departments provide feedback from instruction courses and trial runs with new ships; however, this feedback is not collected systematically and does not always reach the correct addressees. Feedback from experienced navigators, preferably after extended periods of use of an instrument, is the rare exception. Several interviewees mentioned private connections to one or another practitioner which would yield interesting feedback from time to time.

However, quite a number of interviewees fell into what has been called “feedback-trap” (Dörner, 1996) by maintaining that “as long as no feedback comes, everything is OK”.

System Comprehension and Education

We also talked about the necessity of system comprehension: To what extent do navigators need insight into the devices and the relationship between all the bridge systems and functions? And to what extent does this insight actually exist?

Here again, the statements vary between “Any deeper insight into complex functionalities doesn’t, in my opinion, help the crew” and “the user should definitely possess system understanding, however, this is not the case. One can do nothing more than to try to provide the user with an overall picture of the system, that is, to show him what this box over there is actually doing, where are the data transported, what happens to them”. Some thought that system understanding was especially important in critical situations. Then, the navigator should know where his data are coming from, whether they are plausible or what would be the correct reaction to a device failure in the framework of the complete system.

Many designers find fault with the level of education that is insufficient for this degree of insight. Overall, the standard of nautical education has decreased, while at the same time, increased technological complexity would, in fact, require *better* education. Seen from the outside, one could argue that it was the developers' task to adjust to the circumstances prevalent in reality. However, it is also plausible that the manufacturers "always want to have this or that additional function which then justifies the price".

Almost all designers complain about the unwillingness to invest enough money in training and instruction. For them this aspect is very important since it is politically prudent to avoid any rumours of malfunctioning devices which are in fact due to handling errors. We heard many statements like "There is too little briefing during trial runs, these only last two days anyway"; "In most cases the acquisition works via trial and error which takes much time. Often, they change to another ship in between and as a result any increase in experience is interrupted again"; "It so happens that captains don't use a system to its full extent simply because they don't understand it completely".

Still, it appears to us that this criticizing of poor education on the side of the navigators is also meant to divert attention from the fact that many companies' attempts to improve on the users' system understanding are rather limited. Many developments seem to be technology-driven rather than user-driven. This, for instance, is true of the tendencies within several companies to design user interfaces as adaptive systems. Without any doubt this is "chic and trendy" although psychological studies have demonstrated as early as 1989 (Mitchell & Shneidermann) that this is highly dangerous for the development of system understanding.

Errors, Redundancies, Prevention

Navigation allows for errors that cannot be prevented by technical means. Most prominent among these is, according to our interviewees, poor communication with other vessels in the vicinity. On Russian ships, for instance, a navigator is obliged to ask his captain before he can change the course; something he tries to avoid at all costs. Second in importance are manoeuvres for which the ship is not rated but which are executed nevertheless because the navigator experiences severe time pressure.

However, there are many techniques available on the technical level to prevent errors by navigators. During the design process, possible errors are anticipated and appropriate techniques are implemented. For instance, certain operational sequences are protected by passwords and the input of digits is checked for plausibility. However, more complex activities cannot be safeguarded against error because "sometimes they are deliberate, sometimes not". In the same line of argument another designer states that error prevention in navigation is possible only on the level of the single device but not on the level of overall ship guidance: As a designer, "one would not scamp with the craft of the navigator if he puts the helm to the wrong side".

When asked where these ideas for preventive error control came from, we heard quite different answers. Some stressed direct interaction with the user. It was considered important that "things were lifted more on the interactive plane" since "having the manual is one thing, whether it is read and understood is something quite different". Others apparently relied more on their own intuition and creativity: "We then must switch on our brains a little bit and imagine what can happen".

User Adaptability, Culture

Another topic was devoted to the question of whether individual preferences, habits, or cultural differences were part of the thinking during the design process. We considered this to be an important topic; not only because individual differences can play a crucial role in critical situations (Hofinger, Rek & Strohschneider, 2006) but also because almost all merchant ships in the Western hemisphere are operated by multinational crews.

In general, our interviewees argued that there are indeed a number of individually adjustable parameters within bridge systems. This, however, is more due to relevant regulations and technical requirements than to the desire to provide every user with his or her "personal interface". Some designers consider the importance of individual adjustability to be high since this could greatly influence the acceptance of the products. And this was considered especially interesting since it was stated that "within the given structures we generally have great problems in integrating the user into the design process" - which means that individual adjustability is seen as a promising way of user integration.

However, user adaptability can produce critical effects also, especially during the change of watch. Relatively often, some designers argued, crew would manually change some settings and switch off the automatic regulation of a system, since they consider specific data to be false. If they do not relay this information to the next officer on watch, the replacement would be operating on incorrect assumptions. "Generally we solve this by saving error messages in the device and then one has the possibility to have a look". According to some designers, many navigators would also want to have a "Grandma Button" which, once pressed, resets all changes made by the earlier watch into the standard settings.

These arguments show that the designers have both understanding for the different idiosyncratic preferences of the navigators and, at the same time, awareness for the critical aspects of adaptability. As mentioned above, this again emphasizes that a definite position regarding the advantages and disadvantages of adaptability requires more comparative studies on board ships.

With respect to cultural differences among users we generally found little knowledge and also the prevalent feeling that this was not of top importance: The cultural background of a user was considered to be of little relevance for the design of bridge equipment. As is the case with a car: "If you don't like it you just leave it". And once more the organizational constraints were stressed: Basically, cultural context has little influence on the bridge design because every design change implies additional costs which nobody wants to bear. And even if one would think of realizing culture-related variations, legal requirements would make this almost impossible.

Some designers, however, were culturally more sensitive and discussed experiences with different cultural contexts: "We try to meet both the Western European – North Atlantic requirements and take precautions against erroneous inputs that might result from different approaches to certain problems". Examples given referred to certain menu positions which Asians did not even look at, to the stimulative nature of different colours, or to reading habits such as reading from left above versus right below. Even this interviewee, however, admits that the designers are very much bound by a great many regulations.

Technical Developments: Their Meaning and General Purpose

Finally, we asked our interview partners to summarize what, in their opinion, was the general use of their engineering; what was it that differentiates between a navigator on a modern ship with all its sophisticated equipment and his earlier predecessors. The answers can be grouped into two categories which clearly reflect two different philosophies towards technical advancements:

a) The developments of the last decade or so have somewhat lost the benefit for the user out of sight; they, in some ways, outpaced the user. The problem of boredom, for instance, increases with the improved reliability of the equipment. The navigator's tasks become increasingly routinized which makes him less competent in case of failures or problems. Therefore, one should not take all interesting activities away from the navigator: "He has learned something which he is proud of, he wants to utilize this knowledge and he doesn't want to only monitor processes". Designers should take care not to drive the navigator into boredom through advanced technology but rather should leave him to his skilled work.

b) "It finally comes down to the question of whether one really relieves him (the captain) as compared to former times when he had many men who took care of those tasks which nowadays are performed by such a system. As a captain, stress has increased, not as helmsman".

Other aspects mentioned related to the relief of the navigator, to the increase in information availability and therefore the simplification of his tasks with the result of his cognitive capacities not being bound by the "little things" but being free for the broad overview.

CONCLUSIONS

This interview study yielded a number of interesting insights with respect to the aspects that shape –and those that do not shape– current ship bridge design. It is our hope that a critical discussion of these aspects might help with the development of novel design concepts for ship bridges. After all, modularization, standardization and simplification of bridge equipment are generally agreed upon ways of improving safety and efficiency of ship guidance.

First, our discussions with designers from different companies and with different responsibilities generally demonstrated awareness of the importance of the integration of the user perspective in the design process. If there are problems with usability of bridge layout and bridge equipment, this can not be traced to a lack of interest on the part of the designers working in this area.

Second, there was a conspicuous lack of concrete knowledge and the resolution level of arguments deteriorated when the questions went into the details of usability. There was little to come out of the interviews when questions about specific usability-related concepts or workable methods of introducing the user perspective into their work were asked.

Based on this we conclude that there is indeed sensitivity to these concepts and their importance but that there are no structural or organizational systems in place that would allow for a systematic closed feedback loop between users and designers. A similar conclusion was drawn by Nandhakumar and Jones (1997) from their study on user-developer relationships: "Despite the wide acceptance of the importance and benefits of user involvement and the availability of methodologies and prescriptions to facilitate this, in practice the user-developer relationship appears to be less than useful".

Of course, the question arises why this might be so. A first answer can be found in the frequent complaints about the many legal, organizational, and financial restrictions that constrain designers' freedom. Interaction Design only makes sense when there are in fact several possibilities for design solutions. As of now, the conviction that usability and ergonomics may result in long term success and competitive advantages has not yet struck roots with all parties involved.

A second answer might be related to the fact that despite of all the openness to this topic, there is a considerable lack of background knowledge and the possibility to acquire it. Designers are forced to observe a broad set of standards and regulations. Were the rationales underlying them clear, this could open leeway for innovations in accordance with the regulations but still representing ergonomic improvements. However, as Dekker and Nyce (2004) point out, it is also the responsibility of researchers in human factors and ergonomics to phrase their insights in ways that are helpful to designers. Usability is a concept that is applicabe not only to applied design but also to "applied" research.

A third possible answer could be that, although the words "Human Factors" are used widely throughout organizations, this is more like a ritual gesture rather than deeply-rooted creed. "Human Factors" influence on design requires specific knowledge and the willingness to integrate the user's needs, prerequisites and limitations into every step that makes up a design process. It appears to us that in some cases ideas and insights about usability are hidden within the organizations. Occasionally they may surface, often they will not. In organizations designing for high-risk industries one can find specially designated persons or teams that have the responsibility of strengthening usability aspects from within and of integrating the user perspective through various tests and studies. For other industries it might be wortwhile to give such a structural solution a thought. This, however, requires a general strengthening of the visibility of Human-Factors topics and an intensified discussion and their benefit for safety and efficiency within the maritime community.

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