

Design Case Study: MANaging Vessels In Ports (MAN VIP) Project

Ben Brooks and Margareta Lutzhoft,

*National Centre for Ports and Shipping, Australian Maritime College, Launceston, Tasmania,
AUSTRALIA*

This paper reviews the practical and theoretical issues associated with designing maritime technology. It follows the implementation of the Human Centred Design (HCD) component of the HCD and SQA Guideline that was developed under the auspices of the IMO e-navigation initiative. First we describe the project, which focused on the development of a shared interface for pilots and tug masters. Next we describe the implementation of the HCD process. Finally we reflect on some of the challenges associated with the implementation of the process. Implications for the movement of ships in ports, and for maritime technology design are identified.

Keywords: Human Centred Design, e-navigation, ports, user-interface

1. Introduction

The IMO Sub-Committee on Navigation, Communications and Search and Rescue (NCSR), at its second session (March 2015), agreed on the Guideline on Software Quality Assurance and Human-Centred Design for e-navigation. E-navigation is defined as *the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.*” (www.imo.org)

The guideline is intended to ensure that software trustworthiness and user needs are met through the application of Software Quality Assurance (SQA) and Human-Centred Design (HCD) in the development of e-navigation systems. It is also intended to support the principles identified in SOLAS regulation V/15 (Principles relating to bridge design, design and arrangement of navigational systems and equipment, and bridge procedures).

The authors were afforded the opportunity to apply the guidelines in the design of a technology for a group of Australian ports. This technology sought to create a more effective port-based team by providing pilots and tug masters with a shared interface. This paper describes how we interpreted the guidelines and the challenges we faced in doing so.

2. Usability in the context of e-navigation

Historically the concept of usability has been defined on the basis of *semantics, features and operations* (Dillon, 2001). In the first case (popular in the 1970s) usability is identified with not better specified terms such as *user friendliness* and ease of use, rather than a formal definition.

The term user friendly is widespread in the maritime domain, being present both in regulatory documents and in operators' jargon. Nielsen (Nielsen, 1994) argues that the term user friendly is not appropriate for two reasons: firstly because it is unnecessarily anthropomorphic (users need to get the job done and not machines being friendly to them), and secondly because it implies that the relationship between users and the system used can be described in terms of a single parameter.

The feature based approach (popular in the 1980s) defines usability in terms of the presence or absence of desirable features of the user interface. Its weakness is represented by the assumption that usability is part of a specific interface, and not an independent construct. With the operations based approach (starting in the 1990s) usability is defined in terms of task performance and user satisfaction, taking into account operational contexts.

Shackel and Richardson (1991) provided one of the first modern definition of usability of an *interactive system*: “*the capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfil the specified range of tasks, within the specified range of environmental scenarios*” (p.10). Similarly, ISO 9241-11 (ISO, 1998), which 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 his seminal book “Usability engineering”, Nielsen (Nielsen, 1994) frames *usability* within the broader concept of *system acceptability*, which refers to whether the system is good enough to satisfy all the needs of the users and of the organizations to which they belong.

2.1 Guideline on Software Quality Assurance and Human-Centred Design for e-navigation,

In June 2015 The Maritime Safety Committee of the International Maritime Organisation approved the Guideline on Software Quality Assurance and Human-Centred Design for e-navigation.

“The basic premise of HCD is that systems are designed to suit the characteristics of intended users and the tasks they perform, rather than requiring users to adapt to a system. UT is a key component of HCD and uses methods that rely on including users to test the ability of systems to support user needs. UT helps to identify potential problems and solutions during design and development stages by using an iterative approach to testing where the design evolves through rounds of prototyping, testing, analysing, refining and testing again”. (MSC.1/Circ.1512 Annex, page 1)

Figure 1 outlines the activities that should be undertaken in each of the life cycle stages, illustrating the interdependence of each activity. The following HCD activities are carried out to inform development throughout the life cycle:

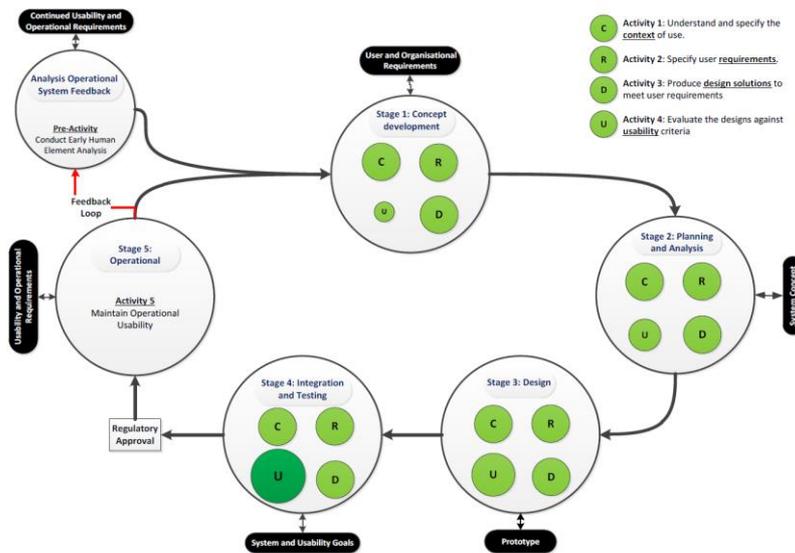


Figure 1 Activities that should be undertaken in each of the life cycle stages of HCD (IMO, 2015)

Fundamental to HCD is the collection of user feedback through Usability Testing (UT). UT is an effective means to discover and resolve potential usability and design issues early as well as throughout the life cycle of a system by using an iterative testing approach to ensure a safe, satisfactory, effective and efficient system. Evaluation through usability testing is carried out iteratively at all stages in the life cycle and provides input for future versions of systems.

3. Methods and Results

3.1 Data Collection

In this project our aim was to implement the guideline. This required a mix of different methods and the section below identifies the methods used and the results in terms of the challenges faced, not just in applying the method but also in communicating the results to the clients.

3.2 Activity 1: Understand and Specify Context of Use

Given the geographical and temporal challenges of coordinating research between multiple international partners, the research team needed a tool to assist with this coordination. We used MindMeister to facilitate that collaboration and identify data that we had previously collected that might be used to understand and specify the context of use. Mind maps were produced for both the broader design process (human-centred design) and for the more specific tasks associated with moving ships in port waters.

For this project, we needed to not just understand the context of use, but it was also necessary to identify the ‘boundary conditions’ or over-arching requirements that had been placed on the project by the client. The most important of these was the requirement to increase safety and efficiency of ship movements, to develop a prototype and for that prototype to be able to be implemented in the current operational environment. The following activities were undertaken in order to identify the opportunities for the prototype to address these overarching requirements and to understand the context of use:

- Observation of tugs, VTS and pilotages at multiple ports around Australia
- Compilation of relevant task analyses.
- Observation of VTS and pilot joint training courses in the simulator.
- Development of work domain analyses for the associated tasks of pilots and tug masters.

3.3 Activity 2: Identify User Requirements

From the set of data collected in Activity 1 we derived a table of user needs that are currently UNMET or PARTIALLY MET, and solution to meet those needs, and the anticipated outcome of meeting those needs. Table 1 shows one example.

Table 1: Example of user needs, solution suggestion and anticipated outcome

User Need	Solution	Anticipated Outcome
<p>Tug captain – needs to maintain their concentration on a large visual field including the ship and the line but also needs certain information, which is currently verbally communicated and held in working memory.</p> <ul style="list-style-type: none"> - Tug power - Bollard pull (on some tugs) - Pilot’s Order 	<p>Augmented reality such as heads up displays can be embedded on glass or developed through solutions such as Google glasses. Information that may be of value includes – ships speed, pilots order and bollard pull/tug power.</p>	<p>This will improve safety for tugs in terms of providing visual evidence of extent to which the tug is working at its operational limits and increased efficiency though better awareness of key metrics of tug performance (orders, engines).</p>

3.4 Activity 3: Produce and/or develop design solutions

From this analysis we produced the first iteration of what a prototype might look like. We began with paper prototyping (essentially hand-drawn sketches) because they are quick, efficient, and low-cost. Paper prototyping is a rapid way to incorporate direct feedback from real users into a design. Because it requires no coding effort, designs can go through a number of iterations in a short amount of time. This is much shorter than the timescales needed for even the quickest computer-based prototyping tools. This led to significant issues with the client due to a misunderstanding on the purpose of paper prototyping. The client thought that this signalled a final output, whereas this was just the first step in ‘storyboarding’ the prototype.

Following the paper prototyping the working prototype needed to be built. At this point the HCD guidelines need to defer somewhat to standard software and hardware development processes. Information models need to be built, code needs to be written and data integrated. It becomes crucial that during this process the essence of the context of use and the early design ideas are not lost. This requires the usability expert to monitor the development process carefully to ensure alignment is maintained.

There is a degree of artistry that accompanies the science (or at least the systematic approach) of doing HCD. Design ideas can be articulated in terms of needs, however this does not seem to accommodate the creativity that accompanies the process in this instance. Perhaps this is partly because this case study was for the development of a new product, rather than a new version of an old product. This leads us to the question: Are we designers? On this particular issue the authors individual views diverge somewhat. One of us thinks of them as, while the other does not.

3.5 Activity 4: Evaluate the design against usability criteria;

ISO 9241 identifies a range of approaches that might be taken to test a prototype. Our first call was to test the prototype using a full mission bridge simulator, linked to a tug bridge. Participants consisted of a distributed maritime operations team all from one Australian port. This included two experienced pilots, and two experienced tug masters. The research team provided two participants; a Captain with a Master unlimited and a helmsman. The aim of the protocol was to test the prototype and to look for opportunities to improve the design. We therefore collected two types of data – usability testing and ship performance data, and data about perceived opportunities to improve the interface.

A single factor design (*device present vs. device absent*) was used for this study. Apart from the baseline simulation run in which no specific events occurred, the testing runs were designed to focus upon a particular hazard common to moving ships in the port environment used in this study.

Data from the simulator was collected and summarised. In order to evaluate the usability or “quality in use” the QUISS scale (Jones, 2008) was used at the end of each of the two days. Furthermore, a questionnaire consisting of 15 statements related to the model of Joint Activity was distributed to tug masters, pilots, shipmasters, and observers during a two-day simulation exercise in which the new technology was used. The eight participants indicated the level to which they agreed with the 15 statements on a Likert scale.

We were also interested to assess human performance, and wanted to understand changes in workload when the device was present and absent. Using modular GSR logger-sensors (Neulog), equipped with RF transmitter modules and custom electrodes (two electrodes attached to a person’s wrist with a Velcro band to avoid issues with the traditional finger-mounted electrodes when operating ships controls), we collected simultaneous GSR signals from the Pilot, the Tug master, and the Ship’s Master / Captain), during both standard training runs, and during runs in which a critical event occurred.

Raw values in microsiemens (μS) for each participant were converted to standardised (z) scores to facilitate comparison between individuals. Values were logged at a rate of 5 Hz for the duration of the simulation runs, which lasted between 30 and 60 minutes. Where possible important events were included in the logs at the operators’ discretion.

Ultimately the value of this approach was to allow the client to ‘play’ with a system that was a working representation of the final design. As pilots and tug masters put the design through different operational contexts they discovered strengths and weaknesses. An attitude of ‘let’s see if we can have fun with it and maybe break it’ is beneficial to the design because we both want and need to test in at the boundaries of performance to discover what is possible. Given at least a desire for high reliability in the maritime domain, this approach has significant merit.

4. Discussion and Conclusions

Our efforts to develop a new e-navigation product afforded us the opportunity to apply the Guideline on Software Quality Assurance and Human-Centred Design for e-navigation. Our conclusions following this application are:

- A balance between formal, informal and emergent approaches to human centred design is important.
- In research there is always the desire to quantify and collect data, however this is not always complementary to building understanding.
- Spending large amounts of time observing normal operations in the port was a significant factor for us in articulating the context of use, and given we were designing a new product, identifying unmet needs.
- We've learnt the need to clearly communicate the developmental pathway of prototyping.
- We've argued about whether we are designers or not, and agreed to disagree.
- We've established in our own minds, the value of 'play' in design.
- We've discovered the value of less intrusive measures of workload in assessing human performance.

Acknowledgements

The authors would like to thank those who participated in this study and those who assisted in arranging the group interviews. This study have received approval by the Tasmania Social Sciences Human Ethics Research Committee, ref. H0013850.

References

- Dillon, A. (2001). *Usability evaluation*. In W. Karwowski (ed.) *Encyclopedia of Human Factors and Ergonomics*, London: Taylor and Francis.: AP Professional.
- IMO. (2015) Guideline on Software Quality Assurance and Human-Centred Design for e-navigation. MSC.1/Circ.1512.
- ISO. (1998). International Standardisation Organization, Ergonomic requirements for office work with visual display terminals (VDTs), ISO 9241 Part 11: Guidance on usability.
- Jones, B. (2008). Quality In Use Scoring Scale QIUSS (pronounced Kee-us). <http://www.processforusability.co.uk/QIUSS/QIUSS.pdf>
- Nielsen, J. (1994). *Usability Engineering*: AP Professional.
- Shackel, B., & Richardson, S. J. (1991). *Human Factors for Informatics Usability*: Cambridge University Press.