IAMU 2022 Research Project
(No. 20220402)

An Experimental Concept of Symbolic Design for Bridge Conning System

By

Liverpool John Moores University

August 2023

IAMU
International Association of Maritime Universities

This report is published as part of the 2022 Research Project in the 2022 Capacity Building Project of International Association of Maritime Universities, which is fully supported by The Nippon Foundation.

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Published by the International Association of Maritime Universities (IAMU) Secretariat
Meiwa Building 8F, 1-15-10 Toranomon, Minato-ku,
Tokyo 105-0001, JAPAN
TEL : 81-3-6257-1812 E-mail : info@iamu-edu.org URL : http://www.iamu-edu.org

ISBN978-4-907408-46-6

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Theme: Human Factors in Digital Maritime Systems

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Abstract Technology is evolving at a dizzying speed. The digitalisation trend influences social actors' practices and interaction, which is reshaping workplaces and way of working. Maritime domain is also involved in, the digital support could reduce employees' physical efforts to enhance the efficiency of operations, however, it also generates cognitive load and mental stress. Contemporary design under the context of digital era emphasizes the perspectives of interaction and service design. "Easy to use" and "intuitive" are often mentioned to describe the desirable user experience (UX) and user interfaces (UI). As the safety-critical domain of maritime operation, a user-friendly interface that creates intuitive interactions is significant. To achieve this goal, metaphoric graphical user interfaces (GUIs) are helpful to shape information from meaningful signs (iconic, indexical, and symbolic) into user's memory through interaction processes, to communicate with seafarers by enhanced sensemaking. This paper demonstrates the development of a conceptual interface for future ship bridge which integrates state-of-the-art technologies, cognitive ergonomics, and human centred design (HCD) principles to create a user-friendly user interface of bridge conning system for seafarers and benefit designing ideal workplaces of intuitive human-machine interaction (HMI) in contemporary industry.
Keyword: *Ship bridge, Interface, Interaction, Symbolic design, Conning system display, Human centred design*

1. Introduction

The development of technology is evolving at a dizzying speed. The digitalisation trend refers to a socio-technical phenomenon and process that influences social actors' practices and interaction, which is reshaping people's workplaces and influencing everyone's way of working. The advancements in digitalisation are also involved in the domain of the maritime industry. Ship bridge is a complex working environment that contains a plethora of interactions between seafarers and technologically supported systems and equipment. Digitalisation reduces employees' physical efforts and enhances the efficiency of vessel operation; however, it also generates cognitive load and mental stress for employees.

Contemporary design has shifted from technology driven and machine-centred design to user-centred design. The role of design is a strategic problem-solving process to deliver innovative products, systems, services, and experiences. In context of digitalisation, interaction and service designers come into the spotlight [1]. "Easy to use" and "intuitive" are terms to illustrate the desirable user experience (UX) and/or user interfaces (UIs) design. "Design is making sense (of things)" [2] and an act of communication [3]. Product semantics and semiotics helps to upgrade the user interface and user experience design. Function, form, and meaning are the three dimensions of design that are collectively pursued by designers. A favourable user interface design can communicate well with users and provoke people's emotions, reactions, and engagements.

In maritime operation – a safety-critical sector, the design of a user-friendly interface that creates an intuitive interaction and assures technology to adapt employees are critical. Deficient graphical UI (GUI) design of ship bridge negatively impacts vessel operations, and undesirable information layout increases potential risks of safety at sea. Symbol, colour, and use of animation (motion graphics) are the three design factors for web-based interfaces [4]. Likewise, these factors are transferable to the screen-based displays of the equipment in ship bridge. It is proven that icons and pictograms that evolve into symbols are the result of the systematic shift of information from the graphical signs to the users' memory through the repeated interaction with interface elements [5]. Once the user-definable and pre-defined symbols shaped, the contents can be visualised and manipulated in a very flexible and intuitive way [6], which helps the designers to effectively develop communication and meaningful interfaces to improve sensemaking for seafarers, and ultimately, achieve the "easy" and "intuitive" experience [7].
This paper demonstrates the periodical developments of a conceptual interface for future ship bridge that reduces cognitive load, minimises human errors, and further enhances employees' working experience. The concept integrates state-of-the-art technology, cognitive ergonomics, UI design principles, and the HCD method to create a simple and user-friendly user interface. The finding will benefit ship designers for future bridge design and can be generalised to create an ideal workplace that assures the intuitive HMI in contemporary industry.

2. Literatures Review

2.1 Metaphors

Metaphors are a powerful concept and method in product semantics and semiotics, widely used in human-computer interface (HCI) design since the 20th century. HCI designers incorporate real-life objects and natural scenes into interface design to provide users with natural and intuitive means of interacting with computer systems [8]. Users process information through schemas, which are representations that can be stored and activated in their memories when interacting with a computer-based system [9]. Schematic knowledge shapes mental models and improves users' understanding of symbolic/semantic relations, enabling them to navigate within and beyond the system. Therefore, metaphors are a common approach to developing effective mental models [10].

Metaphors demonstrate fundamental terms, images, and concepts that users are already familiar with [11], enabling them to relate new information to their existing knowledge and previous experiences. Metaphors not only accelerate users' interpretation of new information but also guide their actions by providing anticipations during system exploration [12]. Currently, metaphors continue to play a critical role in interface design, helping UI designers enhance ease of use. For instance, Apple's Human Interface Guidelines [13] highlights metaphor as one of the design principles across various Apple devices and operating systems. Similarly, Google's Material Design [14] guides all Android designers and developers by explaining "material" as a "metaphor" directly.

The metaphoric designs benefit the context-based designs by figuratively representing interactions between human and environment. Miller and Stanney [15] conducted empirically evaluated experiments to investigate various interface design concepts for a computer-based task completion. They found that both novices and expert users benefited from the picogram-based designed interface, which incorporated metaphorical meanings that closely resembled users' working context.

2.2 Skeuomorphism, Flat Design, Neumorphism, and Glassmorphism

The styles of GUIs design have undergone considerable changes for the last decades. There have been two dominant styles that have opposite visual characteristics: skeuomorphism and flat design. Skeuomorphism is a design style that mimics the real world, representing physical properties such as shape, surface, substance based on reality [16]. For instance, the iPhone released in 2007[13] launches a delightful UI design style: skeuomorphism. Impacted by the pictogram-based favorability heired from early stage of computer-based products, skeuomorphism had won a majority users' and markets' approval. In 2012, windows 8 and iOS 7 updated their UI design theme to flat at the same time, which lead a big turn of UI style & trend. Flat design is a design style that depicts minimal characteristics of the real world, omitting concrete physical properties [17]. A rendered object in the flat style has a two-dimensional (2D) appearance with an abstract form and bold colour [18]. Comparatively, skeuomorphism could provide affordances via visual cues for users intuitively, helping users learn what things are and how to use them [19], while the flat design is supported by its efficiency to convey information without distractions [20].

Neumorphism was first presented in 2019 by Alexander Plyuto, trying to find a mutual point to balance skeuomorphism and flat design. It is meant to make good use of inner shadows to create subtle light effect to reflect 3D feature but not over-represent. Numbers of UI designers found it attractive and adopted the technique to create neomorphism UIs. However, some critics like Iverson [21] criticized that it creates minimal colour contrast between elements, that may cause crucial elements disappearing into the background, becoming unusable.

Apple upgraded the macOS to BigSur with the UI feature of glassmorphism at the end of 2020, since then, glassmorphism came to the spotlight. The glassmorphism style can be tracked back to the time of iOS 7 release and the "Acrylic" UI explored by Windows Vista, the background blur was first introduced to users at that time. Microsoft Fluent Design System explained that Acrylic is a type of Brush that creates a translucent texture for adding depth and helping to establish a visual hierarchy. Glassmorphism creates semi-transparency with blurred background, allowing users to see through from the virtual "frosted glass" while still focusing on the contents on the top "frosted glass". It inherits the texture mimicking from skeuomorphism. UIs become three-dimensional (3D) again. Compared to the 3D style created by skeuomorphism, glassmorphism improves the aesthetic attraction by bold but blurred background colour/image; create multi-layered visual depth by translucent objects with subtle and light border. This trend has been accepted well by both users and designers, it has taken the UI design industry like a storm, Windows 11, macOS, iOS has been adopted it and more applications and products would follow up.

Given the above, different styles of GUI design are not mutually exclusive. Designers may incorporate elements of each style in their projects. The choice of design style may depend on factors such as the proposed interface, the target audience, and the branding of the product or service. Each design style demonstrated both strengths and weaknesses, and designers may choose a style for their project. For example, skeuomorphism may be useful for interfaces that require intuitive interaction and a sense of familiarity, such as in mobile app design, while the flat design may be more appropriate for interfaces that require a modern, minimalist aesthetic, such as in web design. Neumorphism and glassmorphism offer new possibilities for GUI design, allowing designers to create interfaces that combine the best aspects of skeuomorphism and flat design. However, as with any new design trend, it's important to consider the usability implications and ensure that the design is functional and accessible to all users.

2.3 Symbolic Design: The Pictograms and Icons

Candi et al. [22] demonstrated how symbolic design can contribute to the emotional arousal and behavioral responses of products, highlighting the relevance of this design approach in the era of digitalisation. Whether it is a tangible, virtual, digital product, or service/system, symbolic design can provide inspiration and support meaningful interface and interaction design.

Icons and pictograms are graphical symbols that represent objects, concepts, and ideas, allowing information to be conveyed quickly and easily without textual language barriers. Pictograms usually reflect real-world objects with their typical characteristics, such as outlines and silhouettes, for intuitive visual recognition. They are widely used in public spaces as instructions and signages. Icons, however, use design techniques to integrate information with contextual and/or cultural meanings, requiring the audience to interpret their meaning using their knowledge database and previous experiences. Icons are commonly used in digital interfaces to serve as useful linkage signs when people seek information within screen/web-based mediums. They communicate messages more quickly, improve usability and interaction, and have higher visual appeal [23][24].

In contemporary screen-based UI designs, designers should create meaningful and expressive icons that metaphorically reflect real-world objects, imply causation, and symbolise the connotations behind them. Symbolic design cues can also be transformed into identical design languages to build awareness, foster recognition, and create distinctive offerings from a product identity perspective [25].

2.4 Concept Development

The ship bridge is a highly critical environment where safety is significant. A user-friendly interface with intuitive interactions is essential to minimise human errors during vessel operations. This project considers the updated UI design principles and styles while following regulatory frameworks in the maritime domain. The UI design specifically focuses on the Conning, Radar, and ECDIS displays within a ship bridge, aiming to create a simple interface that promotes easy and intuitive interaction between users and machines. To deliver complex information to seafarers smoothly and with minimal distraction, metaphors have been employed in the UI design to help users relate new information to existing knowledge, which will facilitate the building of an accurate mental model for information processing. In addition, alternative GUI styles have been considered to ensure that the final result is both desirable and intuitive.

- ***The Symbolic Concept Generation for Conning System***

The conning system in the ship bridge is an information system that supports seafarers' situational awareness by displaying and monitoring various input data detected by sensors and other automated instruments. It is also responsible for executing corresponding orders and controls. Due to the complexity of the information presented, the interface of the conning system requires logical grouping and presentation of key information to enable efficient access for users from the primary workstation in the ship bridge. The HCD design approach applied in this project focuses on explicit understanding of users, tasks, and environments, and user-centred evaluation driven/refined design: two of six characteristics of HCD [26]. The concept design is based on data collected from primary and secondary research conducted in the early phases of the project.

The UI concept were proposed/categorised into three classifications, the (1) Ship stoff-trackrmation, including heading, course, rudder angle, speed forward, propeller & thruster RPM, ROT, and wind true/relative direction; (2) Meteorology information, including water depth, drift, wind true/relative speed and direction, temperature of air and water, humidity, and pressure; and (3) Route information, including distance and time to WOP, estimated time of arrival, Autopilot modes, and off track error and limit.

A ‘Tab navigation layout’ that takes references from daily-use applications was used for displaying this complex yet logically grouped information, aiming to allow users to access all information easily and efficiently, instead of “click to the next page”. Each tab is presented by a metaphorically developed icon that includes the 'Instructions' to ensure its meaning reflects the real-world object, illustrating the rational correlation, and implying connotations (see Figure 1). All three symbols were designed with unified features of a round squared background and heteromorphic graphical elements to represent meanings and imply functions.

For example, the 'Overview' tab is highlighted by primary gradient colour. Different-sized squares are piled up into a form of a window, metaphorically representing a collection of different information and indicating the function of viewing/monitoring. Whereas the 'Meteo' uses the pictogram of a barometer as a metaphor for its meaning, and the 'Route' applies an arrow with directional connotations to represent the voyage, which is curved, and some circles indicating the WOPs. Equations should be prepared in the most recent version of Word available to the author(s) or any other compatible software.

Figure 1: UI concept example: the tab. (2022)

All the information displayed in the conning system is developed symbolically. At the first, the circular shape is the most used graphical element in this UI concept, as circular shapes are frequently used in ship bridges and other vessel workplaces, such as physical instruments like steering wheels, compasses, and peloruses, as well as screen-displayed information like radar charts. The crew members can easily relate to the circular symbols and understand their meanings of direction, bearing, and range based on their prior knowledge. Then, the circled track is designed as an unenclosed circle with a start dot that gradually becomes invisible, implying the direction and guiding the user's visual stream. To better distinguish the starting point and end, a directional shadow with varying weights has been added, which increases the visual depth and builds information hierarchies. After that, the circled track is consistently used within different contexts. In the illustration of Figure 2, it serves as both an information container and a divider. The starting point is emphasised by a highlighted line representing the north direction of the compass. Detailed measurements are displayed around the circle with intentionally low contrast to minimise distractions.

Other data information with directional meaning, such as wind, heading, and course, utilise the watch-face circle by employing differently designed arrows respectively (Fig 2-a): the wind arrow follows the Beaufort wind speed scale and indicates the accurate direction relative to the ship; the filled arrow overlaid on the ship pictogram runs through the bow and represents heading; and the hollow arrow without tails indicates the course information. The pictogram of the ship in the center is connected to two inner circle bars by subtle lines, demonstrating the vessel's rudder angle. The thicker coloured bars overlaid on the circle track indicate the power of propulsion. The circled track's metaphorical meanings and functions are optimized to display complex information in an integrated illustration with visual hierarchies. By consistently using this graphical element and designing it to convey different meanings in different contexts, the UI concept allows for efficient and intuitive access to information for the users.

Similarly, symbolic design is also used to represent and convey information (Figure 2). For instance, the flowing water is designed using a curvilinear pictogram filled with gradient colours to represent its depth. The two arrows outside the circled track indicate the direction and the level of current wind speed respectively (Fig 2-b). In Fig 2-c, the metaphoric meaning of the track is magnified to express the route and voyage progress. Some shading and gradually disappearing gradient colours are used to distinguish the starting and ending points and guide users' sight.

Colour is one of the three factors of aesthetic design. The light grey is decided/developed based on the background colour (dark grey) aiming to create a harmonious and visual richness effect while minimising distractions. Critical information is presented with high saturation colour (HSL: 190, 100, 68), while other elements are coloured with lower saturation and lightness (HSL: 200, 60, 38). Additionally, a visual 'Light effect' is applied to highlight key information/data.

a b c

Figure 2: Conning system. (2022)

Microsoft Dial (see Figure 3) is a tangible interactive control introduced to the UI concept. As its name and form imply the interactions Dial enables for users are "rotation" and "press", which can be associated with the symbolic connotations of steering and selection. Accordingly, the responsive designed GUI concept is implemented. As illustrated in Figure 4, a transparent symbolic wheel is presented in the interface, with only half of it visible to conserve space occupation and minimize attention. The Dial can be touched to activate the symbol wheel at any time. When the symbol wheel is awakened, it appears fully opaque at 100% visibility for interaction. The wheel is designed as an unenclosed circle with a highlighted curved line to maintain consistency with the overall visual theme and to indicate its association with rotation.

Microsoft Dial shown in Figure 3 is a tangible, interactive control that were introduced to the UI concept. Its name and form suggest that users can interact with it through rotation and pressing actions, which are commonly associated with steering and selection. Accordingly, a responsive GUI concept has been implemented. As shown in Figure 4, a transparent symbolic wheel is presented in the interface, with only half of it visible to conserve space and minimize attention (Fig 4 left). The Dial can be touched at any time to activate the symbol wheel. Once the wheel is awakened, it appears fully opaque with 100% visibility for interaction (Fig 4 right). The wheel is designed as an unenclosed circle with a highlighted curved line to maintain consistency with the overall visual theme and to indicate its association with rotation.

Figure 3: The Dial. (Microsoft, 2022)

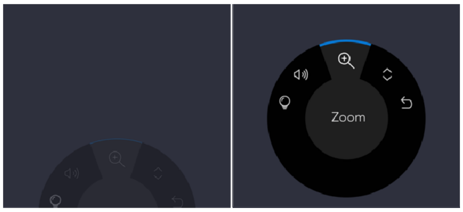


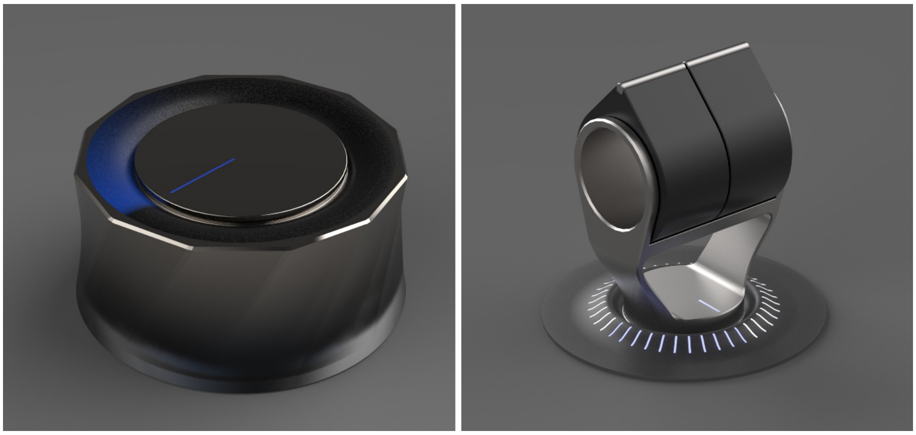
Figure 4: The Dial interaction example. (2022)

- ***Prototype of an Experimental Ship Bridge Concept***

Having followed the design brief, a Tangible User Interfaces (TUI) were developed include: an adjustable (the height) worktop/dashboard accommodated three equipment displaying radar, ECDIS, and conning information at the front edge. The location of each screen is exchangeable, as well as the angle can be converted to satisfy operators' individual anthropometric preference. A physical radar operational panel includes required buttons is set in front of the radar and can be relocated when needed. Three circular bases seated/aligned in front of three screens respectively, to hold two throttles and a dial. The dial is defaulted in the middle; however, it can be exchanged /relocated with two throttles (Figure 5).

- Figure 5. The Tangible User Interfaces (TUI)

The form of thruster and dial are designed with consideration of ergonomics and aesthetics theory to suggest the function, quality, and affordance of the product, e.g., the 'Bone lines' texture indicates the rotating function and suggesting a grabbing area on dial. The circular form on both main body and base of throttle also suggests the rotating feature. The metallic material demonstrated a proposed character trait of the products, such as solid, reliable, precision, and high-quality (Figure 6).



▪ Figure 6. The dial and throttle concepts

Contemporary Graphic User Interfaces (GUIs) design includes two dominant styles with opposite visual characteristics: skeuomorphism and flat design. 'Skeuomorphism' mimics the real world (Norman, 2013) to represent physical properties such as shape, surface, texture based on reality (Bollini, 2016). It provides affordances via visual cues for users intuitively, to help users learn what things are and how to use them (Burlamaqui and Dong, 2016). In contrast, 'Flat design' illustrates minimal characteristics of the real world and omits concrete physical properties (Bollini, 2017). A rendered object in the flat style has a two-dimensional (2D) look with an abstract form and bold colour (Burmistrov et al., 2015), therefore, it conveys information more efficiently (Kuan et al., 2015). In addition, consistency, response/feedback, error prevention, simplicity, and reducing cognitive/memory workload that have been agreed by researchers as the principles of current UI design (Norman, 1983; Shneiderman, 1998; Nielsen and Molich, 1990; Stone et al., 2005). Likewise, Apple latest iOS theme includes 3 keywords: clarity, deference, and depth (Apple, 2021).

Given these, the principles of aesthetic integrity, consistency, direct manipulation, feedback, metaphors, and user control were considered in this experimental concept. We placed shadows to the 'flat design' to establish the skeuomorphic effects. Meaning given by experience, the concept brought daily life experience: the ‘Windows OS’ layout to ship-bridge interface design and parallel information through ‘Tab navigation’ (all in one multimodality interface) design, instead of displaying information over multiple layers. The multimodality interface is distinguished into two functional areas: ‘Main menu’ and ‘content page’ through ‘Indices’ to create ‘depth’. A number of symbols (‘Pointers’ in product semantics) were created/developed based on the IMO guidelines for intuitive recognition, such as ‘Metaphors’ for circular/octagon shapes and ‘Pictographs’ representing vessel and/or other objects. In addition, ‘Light effect’ was used to highlight focal point/information, ‘Micro motion’ was adopted to animate ‘Pictographs’; and all floating panels positioning at the bottom.

Apart from the form and texture, colour is another vital factor to impart vitality, provide visual continuity, communicate status information, give feedback in response to user actions, and help people visualise data. The dark theme was hired in this experimental concept to reduce the luminance emitted by device screens, while still meeting minimum colour contrast ratios (Material.io, 2021). In order to ensure foreground information stands out, and to improve visual ergonomics through reducing eye strain, a monochromatic hue (R:0 G:209 B:255) was selected to display primary information with two degrees of saturation (100% and 60%), so as to establish the hierarchies of information display (figure 7).

▪ Figure 7 (a). The Graphic User Interfaces (GUI)

▪ Figure 7 (b). The Graphic User Interfaces (GUI)

- Figure 7 (c). The Graphic User Interfaces (GUI)

- ***The Evaluation and Discussion***

Focus groups have evolved from their origins in market research (Morgan 1998) to become a versatile qualitative method with applications across various disciplines. Morgan (1997, 6) defines focus groups as a research technique that leverages group interaction to gather data on a predetermined topic. This method proves invaluable in capturing insights from experts or invested individuals within a carefully selected group (Martin and Hanington 2013). By encouraging spontaneous dialogue, focus group discussions mirror natural human communication and reveal participant priorities, shedding light on essential research matters. Stewart and Shamdasani (1990, 19) introduced that in group interviews, participants contribute when they hold strong feelings about a subject, rather than merely responding to questions. As illustrated, focus groups present a powerful tool for qualitative exploration and evaluation, enabling in-depth discussions and uncovering valuable insights. Through methodical planning and skilful moderation, these discussions enhance understanding and drive the evolution of designs and concepts.

In this research project, a focus group discussion was organised to evaluate an experimental prototype through a usability test, to finalise a validated design criterion, thereby to drive the formal prototype of 'A Product of Future Ship Bridge'. Six maritime industry practitioners were invited to participate the usability test (Figure 8). The experimental prototype was presented to collect feedbacks in terms of the users' need, the pain points, and other experience when interact with this conceptual interface. A set of questions were discussed during the three-hour workshop.

- Figure 8. The focus group useability test.

The preliminary results indicate that all participants believe the TUIs concept satisfied their ergonomic and aesthetic expectations, in terms of

- using the ‘dial’ instead of traditional ‘wheel’ to control the direction of ship, in particular in autopilot and control electronic aids.
- the adjustable worktop (in both height and screen angle)
- creating the Modular TUIs/controls panels.
- using either Head-Up Display (HUD) projecting information on front windows or Augmented-Reality (AR) to replace current Look up indicators.

However, some suggestions and improvements are recommended to be used in real working environment and being reliable include

- designing two dials: (A) a steering dial to control direction and (B) an interactive dial to operate the main conning unit separately. Position the steering dial in the middle of the helm, otherwise will be risky and dangerous.
- displaying rudder’s angle on the ‘dial’
- keeping a detachable wheel for backup like F1 cars
- positioning the HUD in/between windows and console table, to avoid altering main windows and allowing the operators to walk close to the front window
- creating a button to switch off easily/quickly when using AR display.
- The throttle has blind spots in its design which needs to improve.
- The modular TUIs/controls panels require major improvement to be used in real workplace.

Likewise, all participants desire the GUIs idea of bringing daily-life experience (e.g., windows OS layout) to ship-bridge interface design for fast/easy learning/recognition. They comment that "this concept can help the user to learn quickly and easy to familiarise”. Participants fancy the concepts of symbol design, layout/material effect to display the overview panel, and positioning floating panels at the bottom. They also accept touchscreen monitor, however, suggest having trackball or mouse as options. Debates have been focused on the followings:

- 50% participants can easily identify the UI has been distinguished into two areas: the main menu and content page and commented “this is an improvement on current systems”.

- 83% participants think applying ‘light effect’ to highlight focal point/information is beneficial. Others concern it “might make the user overlaid with information” and suggest using it on selected/important information and figures only to simplify.
- 83% participants like the ‘Tab navigation’ (all in one multimodality interface) design instead of multi-layer interface. Others suggest having “both settings that allowing operators to personalise to their preference”.
- 50% participants enjoy using ‘Micro motion’ effect when displaying ‘Pictographs’. Others suggest to “include option to switch off” for avoiding distraction.
- 83% participants dislike the Voice User Interfaces’ support in vessel operation, concerning “the language barrier and the different accents could be a problem”, and “get annoying if constantly going off with other alarms”.

The findings of the usability evaluation demonstrate positive feedbacks on both concepts of TUI and GUI. The participants believe these ideas/design concepts are “very accessible” and “easy to understand”. The consistent expectations include “enhancing the current systems”, “keeping the system advanced but simple”, and “making sure the scale of all turning dials is well visible and the information does not overlay when the ship is turning”. However, the focus group feedback also indicating all participants have personal preferences and comforts. The results showing variations and detailed preferences in terms of the style/theme of GUIs and TUIs, applications of preferred technologies in displays and functionality, and advice on improvements for the experimental concepts (see section of The Preliminary Results of the Usability Test).

Given these, research into developing a consistent UI that integrating users’ personalised preference appears to be necessary and desirable. The future solution may integrate seafarers personalised digital preferences into the improved concept that satisfying participants' expectation collected from the preliminary findings. A set of ergonomic UIs may be developed offering different styles in terms of the layout, texture, and colour theme, etc. as options for seafarers.

Applying ‘Microsoft Dial’ technology to create a personal key (a Dial), like the ID card, that can memorise a seafarer’s digital preferences, where the seafarer carry it all the time, when put it on the worktop will log he/she into the system displaying their preferred/familiar style of interface, to seamlessly transfer between shifts and/or vessels. This would increase familiarity/comfort whilst supporting to whom is attached to their personal set-ups. Research may be extended to add extra feature on the ID system to track seafarers working hours, activity, and fatigue/exhaustion levels, so as to prevent risks associated with fatigue. Other idea may also be feasible in categorising all functions into several group tasks (sub-category panels) displayed on the overview panel, such as Berthing, Passing Bridge, On the Sea, so that to create modular options for different tasks. These sub-panels can be easily switched when required.

Two dials are required as one for steering direction and another for editing/interacting with the main conning unit. The steering dial needs to show rudder’s angle and being positioned in the middle of the helm. Three displays are good for navigation, however, one or more displays are needed for supporting information that may not be always required, such as engine room, sonar, and dynamic control. Separating physical control device (e.g., the throttle has blind spots) from the digital displays into isolated islands would avoid distractions occurring. The future concept may consider the older demographic of seafarers’ expectation, as they are more resilient to change compared to the younger, more open-minded participants.

When using HUDs to display look up information on windows, switching on only when the appropriate control is required to receive concise snippets of information to interact with, e.g., showing information regarding throttle/speed when it in use, then disappear after a short period of time.

This would avoid distraction when looking out. Or separating HUDs from the window and position it in/between window and console table allowing the operators to walk close to the window. Likewise, creating a button to switch off easily/quickly when using AR displaying look up information. Further, AR/VR technologies provide solution of using wide-angle/360 overview cameras to show ship blind-spots by rendering a visual 3D environment using the surrounding imagery and offering multiple viewing angles. This concept will be considered in the future concept design.

3. Conclusion

This paper showcases the iterative development of a conceptual interface and interaction design for the future ship bridge, based on the HCD design protocol. The design features metaphoric symbols, which have been emphasised and explored using trendy GUI styles. Preliminary results from a user-centred evaluation confirm the advantages of using metaphorical UI symbols. In addition, symbolising actions provides further design opportunities, with a particular focus on symbolic interaction design within the context of ship bridge operations and culture. The trendy GUI style helps to satisfy users' aesthetic preferences, which are informed by their daily-life experiences. These findings are expected to benefit designers in future ship bridge design and may be generalized to create an ergonomic workplace that ensures user-friendly HMI in various contemporary industries. Further primary research should aim to investigate and confirm the findings clarified in this study and to gain a deeper understanding of the data within the real-world context.

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ISBN No. 978-4-907408-46-6