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CASE REPORT

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Shifting Participatory Design Approaches for Increased Resilience

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OCCUPATIONAL APPLICATIONS

Social distancing restrictions imposed by the global outbreak of COVID-19 exposed vulnerabilities in traditional User-Centered Design processes. This paper presents a shift in methodological thinking and deployment of participatory processes toward a more dynamic and resilient approach of user-centered design in a multi-year joint academia-industry design project. We moved beyond an overreliance on resource-intensive formal discrete events – such as in-person design workshops, focus groups, or traditional field studies and observations – toward including more continuous inputs to create a more sustainable and fluid approach within a living lab ecosystem. User-centered data collection methods were organized in a framework across three dimensions of interaction: 1) *Communication*; 2) *Timing*; and 3) *Presence*. Expanding methodological options along these differing dimensions increased opportunities for more diversified inputs and sample recruitment, while increasing overall data and design feedback collected. Lowering participation and knowledge sharing thresholds enabled more continuous, inclusive involvement of key stakeholders throughout design processes.

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1. Introduction

User-Centered Design (UCD) is a systems-oriented approach that focuses on user needs and requirements in the relationship between human(s), machine(s), and work environment(s), to optimize safety, health, and wellbeing (International Organization for Standardization, 2016). Participatory design aims to engage users in design processes (Bratteteig et al., 2013) and recognizes that the design of products or systems should have input and be shaped by those who use and experience them (Robertson & Simonsen, 2012; Wilson, 2014). A participatory approach aims to bridge specialized knowledge mobilization between multidisciplinary stakeholders, such as the *designers* of systems and the *users* of those systems (Mallam et al., 2017).

Design is a social process (Alexiou & Zamenopoulos, 2008; Bucciarelli, 1988), and participatory design stresses interaction between differing parties to co-create as a team by working together to develop solutions (Carroll & Rosson, 2007). An essential part of implementing successful participatory design is the continuous and iterative interaction between project stakeholders throughout design development. Thus, participatory methods must involve continuous contact, which have typically relied on physical interaction events, such as interviews, workshops, interactive storyboarding, scenario-building, on-site observations, walk-throughs, and prototyping (Bratteteig et al., 2013). However, in an era of social distancing protocols and reduced access to people and sites in the field, implementing traditional participatory methods requires adaptability in order to remain resilient and relevant for ongoing design and engineering projects.

This paper details the methodological and organizational shift in the execution of user-centered development of Human-Machine Interface (HMI) solutions and HMI design guidelines for a safety critical industry in response to the global pandemic. We present: i) the original user-centered approach and execution (2017–∼2019); ii) our initial actions implemented to cope with initial spread of COVID-19 and its effects (2020); and iii) future user-centered approaches and a

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shift in thinking based on these experiences and outcomes (∼2020/2021–). We describe the lessons learned, including the unforeseen positive effects of the global pandemic for more resilient multidisciplinary collaboration and communication. With inspiration from a living lab ecosystem and open innovation approach, we look toward more fluid approaches for stakeholder interactions and knowledge sharing.

2. Background

Ship bridges are the command center of a ship. Operational systems have increasingly migrated to digital HMIs. Design guidance, methodology, and regulations have struggled to keep pace with technology modernization that adequately support detailed digital maritime interface design. This lag has led to differing interpretations and design characteristics of maritime HMIs, creating a lack of standardization across the multitude of systems that make up a single work environment (Nordby et al., 2019). Poor design and implementation of new digital HMI solutions of bridge navigation systems have been identified as contributing factors to accidents and deaths at sea (Mallam et al., 2020).

The OpenBridge Design System is an open-source platform that facilitates both the standardization and modernization of current design practices for maritime HMIs (Nordby et al., 2019). The OpenBridge project depends on close interaction between its academic, industry, and policy-making partners to provide inputs into the design guideline and the maritime equipment developed from the design system. OpenBridge has developed open-source user-interface components, palette, and icon libraries hosted through its online design guideline and vectors graphics editor (OpenBridge Design System, 2021). The OpenBridge guideline includes generic HMI guidance, as well as maritime-specific components, when required. Development of OpenBridge scope and content is directed through the industry's inputs and proposed design cases (e.g., electronic charts, radar, conning, Integrated Bridge Systems, alarm systems), and are developed and apply guidance for real-world systems with OpenBridge design elements (Mallam & Nordby, 2021).

3. Methodological Approach

The development work of OpenBridge is divided between four main areas: 1) design guideline; 2) user-testing framework; 3) technical implementation platform and integration; and 4) authentication for legal approval of use in maritime settings. The focus of the current work has been on the front-end development of the design guideline and cycles of user-testing and Subject-Matter Expert (SME) inputs related to the guideline's elements and subsequent design outputs for a variety of differing maritime equipment.

3.1. Original User-Testing Plan

The OpenBridge user-centered project plan revolved around the implementation of design cycles following the ISO UCD design process of computer-based interactive systems (International Organization for Standardization, 2019) in a multi-methods usability testing and evaluation approach (International Organization for Standardization, 2002; Stanton et al., 2013). SME knowledge transfer and inputs were imbedded across the multi-year project to coincide with front-end guideline and back-end technical development progress and milestones.

Knowledge capture and data collection activities were divided into continuous and discrete interactions, which were carried out synchronously or asynchronously. Continuous interactions included communication via online portals, cloud-based document management, internet relay chat platforms, email, and voice/video calls. Through these various communication channels and platforms the entire consortium, or specific sub-sets of members, could share information, ask questions, discuss, sketch, or brainstorm for specific questions and/or inputs. Discrete interactions usually included the organization of more formalized events relying on typical participatory in-person interactions and data collections, including project seminars, consortium member meetings, design workshops, simulator testing, and field studies (one-day; multi-day; multi-week). The discrete formalized events were where the majority of SME design input was planned to be derived from our project consortium members (see Figure 1). Thus, the success of utilizing participatory processes, and the majority of planned data inputs, depended upon in-person collaboration and knowledge sharing through design workshops, seminars, interviews, focus groups, laboratory, and simulator and field studies.

3.2. Methodological Shift and Rethinking How to Collect and Utilize User Inputs

The initial impact of COVID-19 in the first half of 2020 required all project activities and physical

Figure 1. Brainstorming and sketching with SMEs at a design workshop (*left*) and a field study at sea with navigators on a patrol vessel bridge (*right*).

interactions, ranging from project meetings to shipboard field studies, to cease, thus affecting the major discrete in-person opportunities for user-centered inputs the project originally relied on. Activities immediately moved online in the form of video conferencing systems and collaborative whiteboard platforms (see Figure 2). However, the nature of the participatory sessions changed, including participant interactions and feedback. All parties had to adapt and overcome the learning curve and realign expectations to the new mediums and methods being implemented. This change required a different approach to facilitate co-creation sessions and framing feedback specifically to bridge this new digital gap between participants. Additional attention had to be focused on ensuring that a common understanding and purpose was established and maintained between all parties throughout sessions.

While original participatory interactions were maintained, but now hosted on digital platforms, we began to experiment more with online collaborative tools and graphics editors. This new approach also opened up new possibilities to expand opportunities to collect UCD-related data with larger and more diversified samples, by both expanding to new SMEs within our project member organizations and looking outside of the project consortium itself.

As OpenBridge is founded on an open innovation process, the design guideline is open source for anyone online to access and use. Thus, we decided to shift our UCD mentality toward a similar philosophy. Instead of relying solely on collecting data from our project consortium SMEs, we expanded first to our larger contact network, and through snowball sampling and word-of-mouth began reaching the wider community of national and international maritime stakeholders. Participatory design inputs began to be crowdsourced online through open- and close-ended design evaluations to accompany our digital design workshop sessions with project consortium members. There was thus a shift in thinking about user inputs, from predominantly focusing on the rich, intimate interactions, and data collected from physical and digital workshops, to gathering inputs of static, in-development designs and design sketches from the larger maritime community.

4. Outcomes

4.1. Socially Distanced Participatory Design

User-centered data collection interactions were divided across differing combinations of three dimensions: 1) *Communication* (continuous or discrete); 2) *Timing* (synchronous or asynchronous); and 3) *Presence* (physically distant or in-person). Figure 3 illustrates the organization of the differing data collection methods implemented, divided amongst the three established dimensions. This illustration reveals the diversity of differing methods that can be implemented distantly versus in-person, but also that the majority of traditional UCD approaches are dependent upon discrete, synchronous events. In-person, discrete data collection methods are arguably the "gold standard" of traditional user-centered and participatory design methods, and the methods most compromised by social distancing restrictions.

An immediate finding in transitioning from discrete, synchronous in-person events to discrete, synchronous physically distant events was that socially-distanced design workshops and discussions reduced data richness during the multidisciplinary interactions. The nature of the participatory sessions changed, including the interactions and feedback. This change was in part due to the initial learning curve experienced by all stakeholders adjusting to the new format of interaction. However, the change persisted as communication, specifically design and operations-

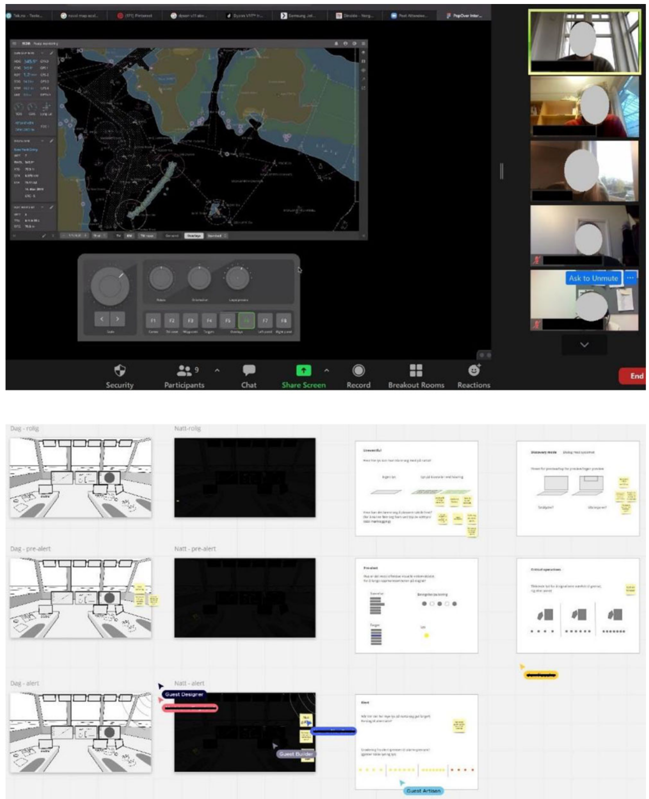

Figure 2. Examples of synchronous online participatory HMI design workshops. Top: electronic chart HMI menu layout discussion. Bottom: reviewing a ship's bridge console design concepts using digital post-it notes and sketching.

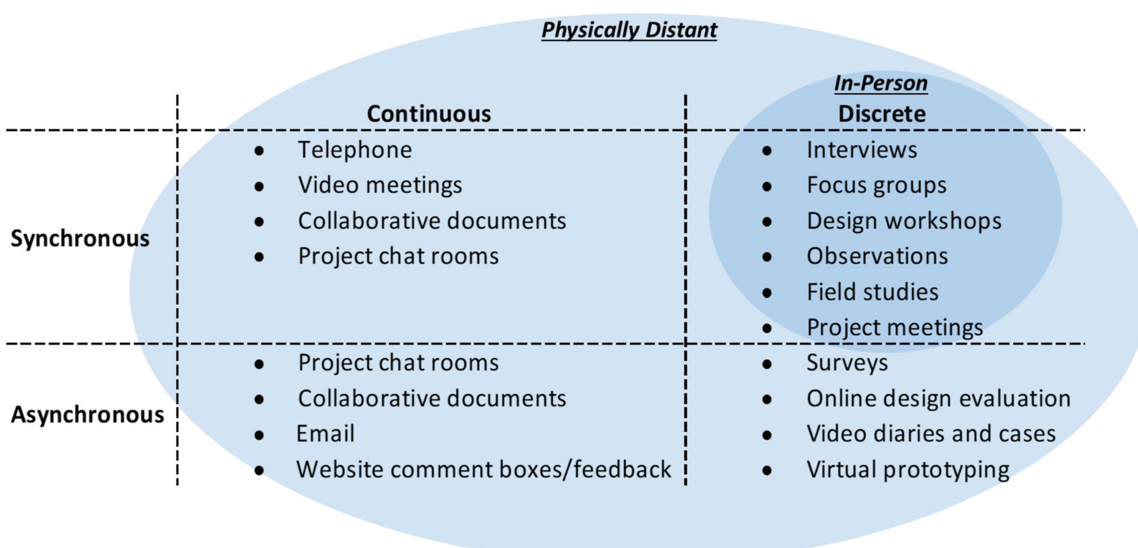

Figure 3. Different UCD methods implemented, organized across three dimensions.

related contextual descriptions and meanings, were lost between multiple persons meeting together online. In general, engagement, interest, and attention levels were reduced, and longer sessions on one particular topic were soon replaced by shorter sessions, involving more variety of activities or topics to reduce the effects of fatigue and boredom. Furthermore, sessions were run with smaller numbers of SMEs (~2–3) in comparison to in-person design workshops (~5+), to stimulate and engage participants in the smaller group setting. The suggested optimal number of users for participation in focus groups varies across the literature and the specific topics of interest, typically ranging from 6 to 8 (Krueger et al., 2001) to 3–4 for design-specific usability testing (Nielsen, 2000). However, our experience suggests lower participant

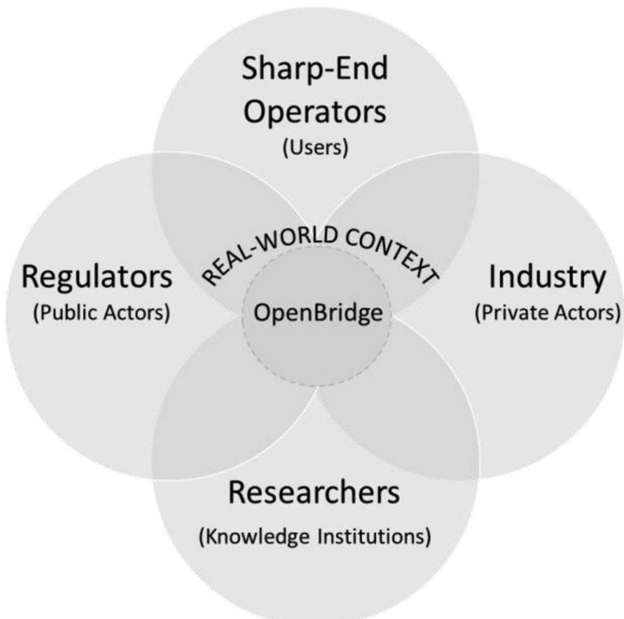

Figure 4. Positioning OpenBridge as a living lab within the maritime domain (adapted from Steen & van Bueren, 2019).

numbers (∼2–3) are more suitable for optimizing participant engagement and interest in online, qualitatively-driven design workshops.

Inputs from outside our immediate project consortium members varied widely. From detailed HMI design evaluations of the latest generated prototypes and design guideline elements, to suggesting specific operational processes, equipment, or onboard work areas that should be addressed in future work. Opening up to the larger network provided new perspectives and feedback for the project and its consortium members. These inputs varied, and though potentially lacked details, context, or validity, have helped identify and/or scope topics for further investigation and development.

4.2. Moving beyond Discrete UCD Events: Toward a "Living Lab" Ecosystem

This experience has made us look beyond the traditional methods of collecting user-centered inputs to differing knowledge transfer opportunities that could be utilized across the larger design project. From predominantly focusing on discrete-event based data collections and milestones toward a more dynamic and resilient approach to user-centered and participatory processes, OpenBridge is increasingly resembling a living lab for maritime innovation (see Figure 4). Living labs are user-centered and open innovation ecosystems, which are based on a co-creation approach and interface between research and innovation that is situated in real-world problems and contexts (Dell'Era & Landoni, 2014). A living lab can be broadly defined as "a real-life test and experimentation environment where users and producers co-create innovations" (European Network of Living Labs, 2015). Living labs offer a unique opportunity to explore approaches for behavior change in a broadly considered context. Solutions are developed that not only facilitate or discourage specific user activities in isolation, but that holistically support change of entire, highly complex social practices, ensuring lasting behavior change (European Network of Living Labs, 2015). Thus, connecting the different specific UCD and communication methods across the differing interaction dimensions within a co-creative living lab creates a more open ecosystem for collaboration and resilience in continuous interactions.

5. Discussion

OpenBridge has shifted from an (over)reliance on discrete in-person, event-focused interactions with only project partners toward increasingly open and fluid interactions and feedback from an expanded set of methods and network engagement. Participatory design as a process can be expensive and resource-intensive, particularly in specialized fields such as the maritime domain. Relevant stakeholders are typically difficult to access, recruit, and engage throughout design iterations. Expanding activities increasingly to digital platforms and to wider audiences across the industry provides opportunities for more continuous feedback across design iterations from a broader group of relevant parties, including those making business development decisions. Furthermore, organizing and implementing data collections and observational studies in naturalistic settings can be challenging for the maritime industry. Access to restricted areas such as ports, ships, offshore structures, or fish farms were resource-intensive initiatives long before COVID-19. Thus, a revaluation of how participatory processes are implemented, to include as many relevant industry stakeholders and examples as possible, can create more inclusive opportunities for SME involvement and feedback acquisition.

5.1. Lower Thresholds, Increase Empowerment and Ownership

An advantage of developing a research and development project with an open innovation approach is that the design system and outputs are available to anyone. It can be argued that the further one moves away from the traditional discrete in-person design workshops and field work, the lower the quality of inputs and data richness. However, if used in combination with in-person, digital, or hybrid methods, an open innovation approach provides a new, larger, and more fluid data source that increases the frequency of contact-points and inputs from stakeholders throughout design development.

Digital collaboration can be used not only as an alternative solution to physical interactions, but also as a supplement that can facilitate the quality and efficiency of planned discrete in-person events, such as interviews, user-tests, and field testing. For example, utilizing lower-threshold, lower-cost digital sessions before and/or after more intensive in-person data collections will facilitate a common understanding and expectations between the multidisciplinary stakeholders. Using digital documentation and communication also extends to real-world worksites, where SMEs, such as seafarers, can provide insights into their work tasks and design-specific needs through such self-reporting techniques as video ethnography, photo diaries, sketches, or text. We look to further reduce the barriers to restricted areas and empower end-users to identify, document, and follow-up on differing real-world issues for which they identify as important to highlight or require change. Empowering workers expertise and perspective through these types of relatively simple methods creates a powerful form of knowledge capture directly by SMEs themselves within their real-world working environment, whilst also reducing or eliminating middlemen and resources in knowledge capture and sharing processes. This provides both valuable insights and context for participatory design processes, as well as being beneficial for more general management and knowledge sharing practices within and across a project(s), department(s) or organization(s).

The effects of COVID-19 necessitated the wide(r)-spread implementation and ubiquitous cultural acceptance of an even faster digital transition. Both emerging and already established technologies were rapidly integrated and relied upon to a much higher degree to maintain societal functions. Advances in IT infrastructure and the collective knowledge of digital systems by individuals and across society has made the accelerated transitions and reliance on digital communication comparatively "easier" and more successfully than if COVID-19 had occurred 20 or even 10 years previously. Whether through easier and more frequent access to stakeholders within an immediate network and project, by eliminating travel costs and time, or through opening up opportunities for interacting with new stakeholders, the fallout from COVID-19 has had positive benefits on how we now approach participatory design and interaction between multidisciplinary stakeholders for design development.

This change has not in itself completely democratized the process or removed all barriers to participation. In the context of the maritime domain, a significant portion of the global seafaring workforce are drawn from developing countries (International Chamber of Shipping, n.d.) where high-speed internet is not as available or accessible in comparison to other regions. Connectivity onboard ships and other marine structures can still be limited, and thus continue to create barriers for participation and access. Furthermore, participation of SMEs within design processes may or may not be supported or compensated by employers or from the project itself. In particularly, in our case, soliciting volunteer participation of individuals from external extended networks is more dependent upon an individual's intrinsic motivation and interest in their profession, as they typically have less knowledge, ownership and direct reward for participating in comparison to internal project consortium members.

Overall, the transition to more digital participatory solutions creates opportunities for more consistent, continual feedback and inputs in comparison to intermittently-scheduled discrete events for SME input. By creating the opportunity to work on the design process over a longer period of time than the traditional discrete events can facilitate concepts are able to mature with participants. Furthermore, all parties are able to gain a larger picture of the entire process by being involved and/or having access to the evolution and rationale behind decision-making, and how differing ideas and solutions matured through their development. This approach increases transparency in the development process and can lead to increased trust from all stakeholders, and thus potentially higher buy-in and support from all levels.

A living lab ecosystem encompassing more open and fluid connections can facilitate inputs not only from end-users or designers, but also from those that develop business models and innovation strategies across the differing stakeholder groups (see Figure 4). Individual projects can become siloed within organizations, where generated knowledge and outputs become isolated and fail to make a broader impact. Creating more accessibility and transparency for the decision-makers increases the opportunities that business development and financial aspects are more holistic, thus increasing potential for broader implementation and value-creation.

6. Conclusions

This case study presents a shift in thinking on how data inputs from participatory processes can and should be used in a more dynamic, resilient approach. A framework was developed to map differing interaction opportunities and types of UCD data inputs across three dimensions (i.e., *communication*, *timing*, and *presence*). Methods consisting of differing combinations of these dimensions were implemented in order to diversify our initial approach and reliance on discrete, in-person design workshops and interactions with internal project consortium members. This implementation has led to creating more inclusive opportunities and fluid communication during participatory design sessions, and has improved the transparency and positioning of the project and its outcomes. The shift toward a larger, more holistic living lab ecosystem aligns with the intention and goals of OpenBridge as an open-innovation platform. Lessons learned will carry over into future practices as a strategy to facilitate more inclusive participative and communicative opportunities by lowering access thresholds and increasing number of contact points throughout design development and project implementation.

Conflict of Interest

No conflicts of interest declared by authors.

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