EMERGING TOOLS FOR CONCEPTUAL DESIGN: THE USE OF GAME ENGINES TO DESIGN FUTURE USER SCENARIOS IN THE FUZZY FRONT END OF MARITIME INNOVATION

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ABSTRACT

This paper discusses and describes how simulated user scenarios can be created and used in the front end of maritime innovation processes. The paper introduces the use of game engines as design tool to create dynamic scenario environments that are used as means to facilitate interdisciplinary collaboration between users and actors in a design process. The goal of the research was to see if it is possible to integrate realistic real-time simulations with user input in the conceptualization phases of innovation. The paper describes a micro case from the maritime industry that shows some of the complexity levels regarding the understanding of user scenarios in interdisciplinary design groups. The second case study reports on an ongoing development project where simulation has been used to explore crisis scenarios in the Oslo fjord. The results show that the use of design thinking and user involvement in combination with simulation tools can create a platform for an iterative process to develop complex user scenarios that drive conceptual innovation.

INTRODUCTION

Conducting user centered design in the Fuzzy Front End (Koen, 2004) of maritime innovation is a challenge. The fuzzy front end refers to the process and activities that comes before the more structured new product development process with traditional stage gates (Cooper 2001). If designing is about "changing existing situations into preferred ones" (Simon, 1981), understanding situations or scenarios is a key element. Problems concerning users are often 'wicked' (Rittel et al, 1973) or ill-defined because factors and solutions are often unknown (Lawson, 2005; Lawson and Dorst, 2009). Dealing with these types of problems often requires a more radical approach in contrast to incremental development where the goals are often increased product performance.

In order to explore and understand such unknown factors, designers need approaches other than what is currently the practise in the maritime industry. In addition, one of the bottlenecks for implementing new types of conceptualisation processes in the industry is the complex nature of maritime innovation on multiple levels. These include:

- Design and development are often dependent on collaboration between multiple companies within a maritime cluster
- The maritime contexts at sea are often not available for experience by the designer
- Products and systems often contain a range of different technology
- Carrying out task analysis is often a challenge because of the complexity of operations
- Testing new concepts is often not possible because of matters of safety and risk.

Emma Linder (2008) and Jan Inge Jenssen (2003) describe some of these innovation challenges.

The first part of this paper explores some of these challenges when effecting user centred design through a case study where a new seismic simulator was designed. Through participatory action research and qualitative interviews we explored answers to the following question: How is it possible to understand and analyse complex user scenarios via simulation in the maritime and offshore industry?

Based on results from this study we proposed a game engine tool to simulate scenarios that can be created in the design conceptualisation phases of the activity. The porous character of this tool lay in the ability to create and visualize complexity in a way that more easily allows designers to obtain a holistic overview and enable fast design modifications.

Existing research about the use of simulators and VR tools in early product development phases shows that user scenario simulation improves information quality and quantity from end-user feedback that can identify usability issues (Thalen, 2011). However these areas tend to focus on creating life-like interface experiences for user evaluation and not on the potential as an iterative design tool.

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When these types of tools have been used for conceptualisation in design processes they often only utilize the real-time rendering engine to walk through static 3D models. The *Lumion* simulation software is an example of this. This application of the tool might cover the needs of architects designing buildings to develop an more immersed experience of a design concept, but it offers little flexibility when designing for complex maritime tasks or operations where a more dynamic approach to behaviours is needed. The central question this paper tackles is how game engines might be used as a design tool to visualize and simulate user scenarios for conceptualisation in maritime innovation.

MARITIME INNOVATION AND INDUSTRIAL DESIGN

The maritime industries often have a conservative approach to innovation strategy that is lodged in decades of experience. This industry typically uses engineering methods to design and solve most of its problems. These problems are mainly technical or systems oriented where human input is a sub-factor of the overall innovation strategy.

Innovation and operation in the maritime sector have seen increased interest in human safety and operation performance. If a human focus is needed in design, it is often referred to as human factors or ergonomics (Meister, 1999). The problem with human factors in the maritime sector is that its not implemented in the core design activities in the innovation processes that are undertaken. The reason for this is that engineers are not trained in designing for user experience or with human factors orientation. Human factors are then often seen more as requirements than innovation possibilities. This gap in competence in the maritime innovation process has opened up possibilities for industrial and interaction designers with special competencies in design thinking, engagement and user centered design.

Recently, some projects in the maritime sector have included industrial designers as part of their core innovation strategy. The K-Master operator chair (Figure 1) project carried out by industrial designer Magne Høyby in Hareide Design is a good example not only of how design thinking and human factors can be part of an innovation strategy, but also how the design process itself can manage the conceptualisation phases in collaboration with technical engineers.

Figure 1. K-Master operator chair designed for Kongsberg Maritime by Hareide Design

SIMULATION

Simulation tools are often used in late stages of innovation where tests are made to evaluate a finished design. When human factors are simulated, tests are often performed in simulators that are costumed designed for training purposes. Simulators might be very useful in user evaluation and in usability testing, but they are often not used until later stages in the development process where changes of the design are costly.

One challenge with simulation software is that it is not designed to be used as a tools in conceptualisation processes. Creating simulations can be time consuming where considerable programing must be implemented even to do simple task such as importing 3D models. Often these types of programing tasks are preformed in low-cast representations.

3D CAD tools have eventually become crucial in product development, but the tools are not basically designed for creative cross-professional design processes, where “changing existing situations into preferred ones” (Simon, 1981) is at stake. Laurel (2003) describes how visualisations and models are created to simulate future scenarios that are often used in the final presentation of concepts and not as creative tools in the conceptualisation phases when designing.

The idea of using 3D game engines as a tool in the design process is to improve the ability to understand existing and develop future user scenarios much earlier in the design process (Tideman 2008; Thalen 2011; Manninen 2000). There are several types of game engines on the market and the most popular is *Unity*, *Unreal engine*, and *CryENGINE*.

A game engine is a software framework that is used to create games for platforms like *Xbox*, *PlayStation* or personal computers. Typical functionalities are 2D or 3D graphics-rendering engine, object collision detection, physics engine, animation integration, artificial intellegance, sound integration, scripting and network extensions. All these functionalities can be simulated simultaneously to create realistic game experiences. Such tools can be used to simulate existing and future user scenarios in development of products, systems and services.

Simulation needs immersion and immersion allows the user to experience the simulation in a way that stimulates possibilities that otherwise would have been impossible (Turkle 2009). Squyres (2006) describe such simulation cases that have been designed on screen, like structuring molecules in virtual space, nuclear explotions and controlig a romotly operated vihicle on Mars. At the same time as immersion is beneficial it makes one also vulnerable if the model and outcome are not seen with critical eyes (Turkle 2009). Immersion has seductive capabilities that overshadow the real implications of simulation.

In the case described in this paper there are two levels of immersion. One is the software visual simulation it self that aims to create realistic representation of the scenarios, and two the screen system that displays the simulation. Both are important in order to create the overall immersive experience of the simulation.

Design places like the *Envisionment and Discovery Collaboratory* have been made in relation to dealing with human computer interaction and simulation systems in collective design process (Arias 2000). The idea is to create a system where an interdisciplinary team will more easily address implications based on their background from a shared visual perspective.

This can be realised by drawing on the notion of co-design (Sanders and Stappers 2008) and participatory design (Ehn and Löwgren 1997). In these approaches where externalisations of ideas and knowledge are made to create shared understanding and facilitate collective creativity (Sanders and Rim 2001) between interdisciplinary actors.

Figure 2. Jernbaneverket shows different alternatives for new railroad tracks using visual simulations in the SimSam-lab at Vestfold University College.

In this research we have been using a visual immersive system *SimSam* (Figure 2) that allows a team of actors and users to experience the simulation simultaneously in a design place (Jan & Hjelseth 2012). The wide angle of the screen covers more of the view angle of the actors and gives stronger sense experiences that raise the level of immersion. This can sometimes have negative effect where the actor feels seasick. The CAVE [Cruz-Neira et al., 1992], is another example of an visual immersive system designed to explore and interact with virtual environments.

The most common argument for why these tools are used in product design processes is that the software itself is oriented towards software engineers and that the game engine editors require a great deal of programing code. The trend in the development of game engines is to create editors with interfaces that do not require a lot of programing and that it is possible to create simple games and simulations with a minimum knowledge about codes (Kraus 2012). With the introduction of touch interface devices like the iPad and the iPhone there has been an increasing interest among designers to use 3D game engines to create tangible applications. The Oslo School of Architecture and Design has now integrated game engine tools as part of their master courses in interaction design in order to explore the use of such tools in design practice.

RESEARCH METHODS

An explorative research methods was used in case studies to develop and explore the simulation and simulation tools in relation to design processes. This was based on existing methods and knowledge about the use of scenarios in design conseptualisation phases, co-design and 3D software expertise. In the cases presented here this author researcher has been actively involved in the design activities that have been placed within a methodology drawn from participatory action research (PAR) (Hult and Lennung, 1980; Denzin and Lincoln, 2000). Through the use of PAR it was possible for the researcher to get an holistic experience of the process when designing the simulations and its relevance when used in a co-design workshop with multiple actors.

Empirical data based on observations during design workshops was produced through the case studies in real-life situations (Yin, 2009). The obervations focused on the way the simulation and the simulation tool was used by the designer and participaticipants during these workshops. It was observed how actors established a shared scenario understanding, created analogies to other scenarios, and how ideas or suggestions to change were stimulated.

The engineers, project maneger and customers in the PGS case study were interviewed using a qualitative interview method (Kvale and Rygge, 2009). This interview method allowed for a subjective and personal insight in the actors' own experience of design tools used in the design process.

DESIGNING THROUGH SCENARIOS

Referring back to our qualitative interviews with Kongsberg Simulation, one of the leading simulation companies in the maritime market, we have seen been increasing interest in the maritime and offshore market to simulate future scenarios. One of the goal with this type of simulation is to get a full overview of the scenarios so unknown factors can be discovered and solved.

Implications of carrying out user studies in the maritime domain have been researched through a micro case study in a design process of a seismic streamer recovery simulator at Kongsberg Simulation. The starting point for the design team was a technical system oriented approach to understand the recovery operation. The problem with this approach was that the user's perspective was not addressed at this early stage and was supposed to be implemented later on in the process. The design team found it hard to understand the user scenarios based on written description from users with pictures and small video clips. This "task oriented" method is being applied in their more incremental processes where small changes are done to existing products. The problem of obtaining a shared understanding between the engineers delayed the whole project for six months. To understand the scenarios from a user's perspective, a new approach was needed. In order to obtain a better overview of the whole process we placed five action cameras on different positions and two of them where mounted on the heads of the winch-operators. Through this multiple angle view (Figure 3) it was possible to link the users' tasks to the overall recovery operation scenario.

Figure 3. Video of the seismic recovery operation with multiple view angles showing overall operation view, and tasks performed by crew and winch operators.

This design process showd that it is difficult to understand complex scenarios in the maritime industry. The interviews from this case study showed that the ability to have multiple view angles gave a much better understanding of the scenarios complex user scenarios. One interviewee, for example, mentioned that the video material was very important to help everyone to understand what was happening and that having good video material is not to be underestimated when trying to understand this type of operations. A more detailed description and analysis of the interviews will be published in a future article.

Findings

A number of findings were drawn from this study. These were that:

- User tasks in maritime and offshore operations are often complex
- Existing float diagrams are sometimes to complex to get a holistic overview of the user task
- The float diagram has a problem of creating a shared understanding within the design team.
- Collecting user information trough probes did not give a satisfied overview, and tacit user knowledge was not implemented
- A combination of video and user involvement improve understanding of the user tasks
- Multiple view angle cameras provided the means to understand simultaneous operation in a holistic view.

ONGOING CASE STUDY: SIMULATING CRISIS SCENARIOS IN THE OSLO FIORD

The background for this case is is the development of a new ferry concession between Horten and Moss in the Oslo fiord. In the new concession it is proposed that number of departures be increased in response to increased vehicle traffic. The ferry line is already the most profitable in Norway. Yet, the Norwegian Coastal Administration has reported that the Oslo fiord is the most hazardous coastline in Norway. The development group Maritime Competence Oslofjord (MKO) is a combination of different companies that have started a project to look at different risk factors in the Oslo fiord that opens for new product, services or business opportunities. The project has been developed and facilitated through workshop meetings with interdisciplinary participants.

The first workshop was about finding existing risk scenarios and possible future risks with the increased ship and ferry traffic. Part of this workshop included participation by former captains, vessel traffic central (VTS), ship pilots, Norwegian Maritime Education (NMU) and the Norwegian Coastal Administration. To facilitate discussion we used acrylic ship models on a Microsoft Surface screen where we displayed different types of maps and AIS information (Figure 4). The participants used the models as boundary objects to explain different risk scenarios (Figure 5). These typically include tangible objects that can be transformed or arranged in order to communicate ideas or knowledge. Examples are: clay models, foam models, drawings, paper mockups, CAD models, rapid prototypes or pictures.

Figure 4. Actors interacting with ship models on a multi-touch screen.

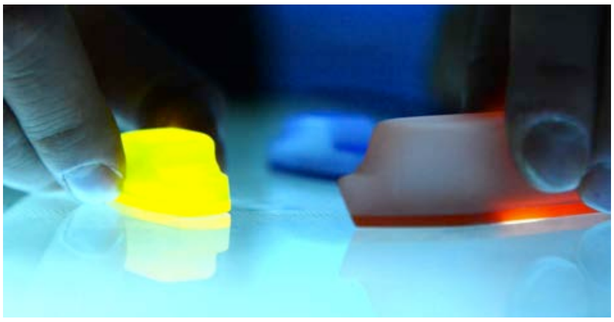

Figure 5. Acrylic ship models.

After the workshop different risk scenarios were simulated in the game engine. The surrounding landscape was auto-generated in 3D using data from *NorgeDigitalt* and also textured using pictures. The boat 3D models were downloaded from Google Warehouse and imported into the game engine with existing boat-vehicle scripts that allow for AI behaviour, collision detection, physics and hydrodynamic properties.

In the second workshop (Figure 6) the goal was to explore the risk scenarios and discuss possible ideas and solutions. Different local companies, organisations and ship captains represented the assembled and key actors.

Figure 6. Interdisciplinary actors discussing possible VTS applications when using the simulation as means to stimulate discussion in the second workshop.

Figure 7. Crisis scenario in which a cruise ship has hit a containership in the Oslo fjord.

By using the simulated scenario (Figure 7) the captain explained the different risk scenarios to the other actors. The scenario took place before, during and after ship accidents. Through the game function it was possible to play different crisis roles that were part of the scenario. The game function enabled better user participation where participants could play an avatar role to share their knowledge end experience.

When a scenario is created it is possible to include multiple user inputs in combination with artificial intelligence and avatars. Consequently, design workshop participants play roles as captain, passenger (Figure 8), ship, crew, rescue boat or rescue helicopter (Figure 9) in the same scenario. This allows for a better understanding across disciplines and experiences, and offers a means to visualize and interact with the complex nature and processes of the crisis.

Figure 8. Avatar view from passenger who has jumped into the water.

Figure 9. The avatar view from rescue helicopter when approaching the sinking ship.

Based on the simulation, the design actors then created ideas and new concepts on VTS systems, crisis management plans, new training courses and automated ship docking systems. The aim of this move in the process was to create a collective understanding of the different user roles and to see how they influenced the overall crisis. This enabled new approaches to understand the crisis scenario from different user perspectives and inspire new ideas for innovation.

DISCUSSION

The results of the first workshops show that it is possible to use the game engine as an iterative design tool for design conceptualisation. One of the most important functions to the tools used to create concepts is the ability to utlise a fast workflow. The use of ready-made 3D models makes this workflow easier, but if the design project requires a lot of custom modelling it might create a bottleneck in the work pipeline.

The fuzzy front end of innovation is never predictable and the use of design tools changes according to problems, actors and context. To use game engines to simulate scenarios in a design workshop is relatively more complicated than working with low-fidelity boundary objects like physical mock-ups, cardboard models and rapid prototypes. Tim Brown (2008) argues that:

Prototypes should command only as much time, effort, and investment as are needed to generate useful feedback and evolve an idea. The more "finished" a prototype seems, the less likely its creators will be to pay attention to and profit from feedback. The goal of prototyping isn't to finish. It is to learn about the strengths and weaknesses of the idea and to identify new directions that further prototypes might take.

The initial phase of using the game engine to create the scenarios is more time consuming in relation to more traditional methods, but the iterative process is very fast because of the layered based structure of working with 3D models in real time environments. Adding new items and modifying the scenario is much faster when the initial phase of creating basic elements are in place. The rendering technology used in the game engines creates automatic hi-fidelity realistic images that might give the feeling of more finished result; it has not shown any negative effects when ideas to concepts are created. However if the simulations have behavior error or digital artifacts it might draw attention.

On a more negative note, the use of game engines might not be suitable as a design tool in all contexts in the fuzzy front end, however, more optimostically, it has shown to be valuable in the conceptualization phase in maritime innovation.

CONCLUSION

Maritime innovation processes are complex and may require different and untraditional approaches when designing for diverse users who face different degrees of complexity and situations of ease and risk. However, the industry often lacks competence in how to fulfill user centered design, and human factors are often seen more as requirements than innovation opportunities. As an early counterweight to such perspectives, this paper describes some of the complexity levels regarding user centered design in maritime innovation.

The use of game engines to visualize and simulate existing end future user scenarios in the design conceptualisation phases were introduced. The results from what is still an ongoing case study show that it is possible to implement this tool and that it allows an iterative conceptual approach within the front end of innovation. The actual tested scenarios and simulations provided experiential settings and contexts of collaborative engagement and dialogue that offer alternatives to building richer understanding of the complexity of contextual activities on the sea.

Using simulated behaviours and artificial intelligence in combination with realistic visualizations enabled our small experimental group of interdisciplinary design participants to develop fuller and more holistic overviews of complex scenarios. In addtion - and importantly for design in the martime sector - the usability friendly interface of the game engine enabled the designer to modify and add the simulated scenarios during the design workshop. The tool also allows expert users to share their knowledge and experience through the role of an avatar in the scenarios that improves feedback information quality and quantity.

Taken together these design rich aspects of involving simulated uses in critical settings in the maritime sector may help enhance our perception and responses to fiend critical experiences and emergent an given needs. There would appear to be further room to investigate the role of design in the fuzzy front end of wider innovation processes in the sector so as to improve consistency and clarity in safety, operations and shared activities that unfold in contexts of use.

REFERENCES

Arias, E., Eden, H. 2000. "Transcending the individual human mind and creating shared understanding through collaborative design." *ACM Trans. Comput.-Hum. Interact.*, *7*(1): 84-113.

Cooper, R. G. 2001. *Winning at New Products*, 3rd edition, Perseus Publishing, Cambridge, MA.

Cruz-Neira, C., Sandin, D. J 1992. "The CAVE: audio visual experience automatic virtual environment." *Communications of the ACM*, *35*(6), 64-72.

Brown, T. 2008. "Design Thinking". *Harvard Business Review, The Magazine,* June, 84-96.

Denzin, N., Lincoln, Y. 2000. *Handbook of Qualitative Research.* Thousand Oaks, Calif., Sage.

Ehn, P., Löwgren, J. 1997. "Design for Quality-in-Use: Human-Computer Interaction Meets Information System Development," In M. G. Helander, T. K. Landauer, & P. V. Prabhu (eds.), Handbook of Human-Computer Interaction, Elsevier Science B. V., Amsterdam, pp. 299-313.

Hult, M., Lennung, S. 1980. "Towards a definition of action research: A note and bibliography". *Journal of Management Studies*, *17*(2), 241-450.

Jenssen, J. (2003). Innovation, capabilities and competitive advantage in Norwegian shipping. *Maritime Policy & Management , 30* (2), 93-106.

Koen, P. 2004. "The Fuzzy Front End for Incremental, Platform, and Breakthrough Products". *The PDMA Handbook of New Product Development,* John Wiley & Sons, New York: pp. 81–91.

Kraus, M. 2012. *User-Centered Design of GPU-Based Shader Programs.* In Richard, R., & Braz, J. (Eds.), *Proceedings of the International Conference on Computer Graphics Theory and Applications: GRAPP 2012*. (pp. 248-253). Portugal: Institute for Systems and Technologies of Information, Control and Communication.

Kvale, S., Rygge, J. 2009. *Det kvalitative forskningsintervju. (The Qualitative Research Interview).* Oslo, Gyldendal akademisk.

Rhea, D. 2003. "Bringing Clarity to the 'Fuzzy Front End'. A predictable process for innovation," *in: B. Laurel; Design Research. Methods and Perspectives.* Cambridge, Mass.: MIT Press, pp. 145-154.

Lawson, B. 2005. *How Designers Think: The design process demystified.* 4th edition. Oxford, Elsevier.

Lawson, B., Dorst K. 2009. *Design Expertise.* Oxford, Elsevier.

Linder, E. 2008. "Industrial designers in the offshore ship design industry". *Paradoxes within Design Research – Mechanisms and Contradictions, 7th Nordcode Seminar & Workshop.* Lund. Division of Industrial Design at Lund University 2008.

Manninen, T. 2000. "Multimedia Game Engine as Distributed Conceptualisation and Prototyping Tool - Contextual Virtual Prototyping". In *Proceedings of IMSA2000 Conference*, November 19-23, Las Vegas, Nevada, USA, IASTED/ACTA Press.

Meister, D. 1999. *The History of Human Factors and Ergonomics*. Mahwah, NJ, Lawrence Erlbaum Associates.

Rittel, H., Webber, M. 1973. "Dilemmas in a General Theory of Planning,". *Policy Sciences*, *4*, 155–169.

Sanders, E., Rim, L. 2001. Collective Creativity, *LOOP: AIGA Journal of Interaction Design Education*, *3*, 1-6.

Sanders, E., Stappers, P. 2008. "Co-creation and the new landscapes of design." *CoDesign,* *4*(1), 5-18.

Simon, H. 1981. *The Sciences of the Artificial.* Cambridge, Mass., MIT Press. 2nd edition.

Squyres, S. 2006. *Roving Mars: Spirit, Opportunity, and the Exploration of the Red Planet*. The University of Michigan: Hyperion Books.

.

Thalen, J., Voort, M. 2011. "Turning VR into something useful. A case study on electing requirements for virtual reality design tools". *Diversity and Unity: Proceedings of IASDR2011, 4th World Conference on Design Research*. Delft: TU Delft 2011, p. 738..

Tideman, M.. Voort, M. Houten, F. 2008. "A new product design method based on virtual reality, gaming and scenarios." *International Journal on Interactive Design and Manufacturing (IJIDeM*), ***2***(4), 195-205.

Turkle, S. 2009. *Simulation and its Discontents.* Cambridge, Mass, The MIT Press.

Yin, R. 2009. *Case Study Research: design and methods*. Los Angeles, Sage.

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