Meeting the Complex and Unfamiliar: *Lessons from Design in the Offshore Industry*

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Designers increasingly find themselves working in unfamiliar fields with high levels of complexity. One such field is the offshore industry. Through qualitative research interviews with eight industrial and interaction designers, we have investigated how designers experience designing for the Norwegian offshore industry, identified the challenges designers face, and examined strategies used for meeting the challenges they experience. The study shows that offshore-specific design projects are found to be complex at many levels, and the designers interviewed described a number of challenges that make it difficult to gain the insight needed to develop adequate designs. They employ different strategies for coping with these challenges. Systemic approaches, which have proven valuable when designing for other complex issues, are used to differing degrees by the designers interviewed. We propose that systemic approaches could help designers in this field get a better understanding of both the system they design *for* and the system they design *within*.

Keywords – Designing for Unfamiliar Fields, Complexity, Offshore Industry, Systems Thinking.

Relevance to Design Practice – The study presented addresses designers' experience with designing for the offshore industry, a complex high-risk field normally unfamiliar to designers. The research results are considered relevant to designing for other fields of similar complexity.

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Introduction

Design is expanding into new areas with high levels of complexity. As a result, industrial designers and interaction designers often find themselves in unfamiliar fields—fields that designers are not traditionally trained to design for and where designers have limited personal experience to draw upon. Examples include designing for professional and expert users, designing for industrial settings, designing for hard-to-reach populations, and designing for different kinds of organisational and societal issues. By "complexity" we refer to systems that contain a large number of parts interacting with each other and their environments on multiple levels, making it difficult to understand cause-and-effect relationships. One such complex and unfamiliar field is the offshore (petroleum) industry. In the study presented in this article, eight professional industrial and interaction designers with experience with the Norwegian offshore industry were interviewed. The objectives of the study were to investigate how industrial and interaction designers experience designing for the offshore industry, to identify the challenges designers face, and to examine the strategies used to meet these challenges. We have also initiated a discussion on *if* and *how* systems thinking could be of relevance in offshore-specific design projects.

Background

The Norwegian offshore industry has been involved in exploration activities, field development, infrastructure creation, and production of oil and gas on the Norwegian continental shelf since the 1960s (Norwegian Ministry of Petroleum and Energy, 2014). The industry consists of owners and operators of the fields, as well as partners, service providers, and other actors providing support for these activities, e.g., offshore shipping companies. This industry is a typical example of a complex, high-risk industry (Perrow, 1999). The focus of such industries is on efficient and reliable production without compromising either human safety or the environment. The offshore industry depends on continuous innovation in order to achieve these goals in a high-cost country such as Norway. Naval architects and engineers traditionally have been in charge of these innovations, while industrial designers and interaction designers (in the tradition of industrial design, as described by Moggridge, 2007) have not played a role.

Over the last ten years, however, the Norwegian offshore industry has seen a change in attitude towards the use of designers. The Norwegian Design Council has observed an increase in interest from the design field (K. Bang, the Norwegian Design Council, personal communication, August 29, 2013). Not only does the council see more companies from the offshore industry

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using designers, they also see that the nature of the design assignments has changed. Previously, if designers were engaged they were mostly hired late in the process to "style" individual equipment, while now designers are more often involved earlier in the process and in projects with a wider scope: even the design of whole vessels and entire ship bridges. Further, in the last ten years some Norwegian design consultancies have started promoting their services more actively towards the offshore industry, and some Norwegian providers of maritime and offshore products and services have started employing in-house designers. The designers interviewed in the study presented here work at such companies.

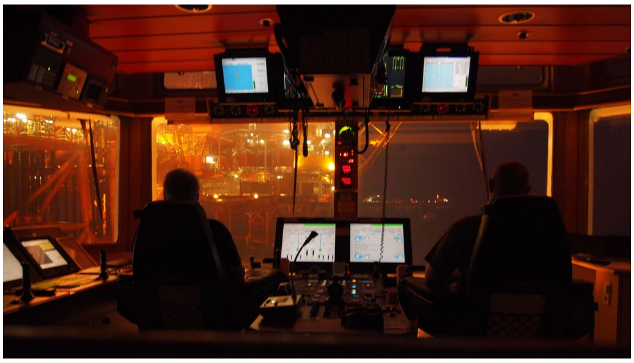

Figure 1. Example of a setting to design for in the offshore industry: The ship's bridge of an offshore service vessel discharging cargo at an oil rig. Photo: Sigrun Lurås.

Despite this tendency, little research has been conducted on the use of industrial and interaction designers in the offshore industry. Linder (2008) has discussed how industrial designers can contribute to innovation in the Norwegian offshore ship industry; Lurås (2012) and Sevaldson, Paulsen, Stokke, Magnus, and Strømsnes (2012) have initiated a discussion of how designers can cope with complexity when designing for this field; and Lurås and Nordby (2014) have discussed the role of field research when designing a ship's bridge. Looking at maritime research in general, little attention has been paid to industrial and interaction design, even though the maritime human factors research community has argued since the 1970s that it is not the technology that needs improvement on ships, but rather the design of equipment (Lützhöft & Nyce, 2008). Several studies have concluded that the design of the technology on ships does not support the mariners in a satisfactory manner (e.g., King, 2000; Lützhöft & Nyce, 2008; Mills, 2006; Olsson & Jansson, 2006). A common assumption in the maritime domain, however, has been that user-friendly systems are not necessary since the users are experts (Grech, Horberry, & Koester, 2008). This assumption has been challenged in recent years, and more human-centred approaches in maritime product development have been proposed. Koester (2001), Mills (2006), and Petersen, Porathe, and Lützhöft (2011) discussed the importance of domain knowledge and a thorough understanding of the context of use when designing for marine settings, and Petersen (2012) has suggested that usability standards should be implemented in the maritime domain. Within the field of human-computer interaction, we can find some research related to design for the oil and gas sector. Heyer and Husøy (2012) discussed the uniqueness of designing for an oil and gas workplace, as this industry is outside most people's everyday experience, and Husøy, Gaver, and Enkerud (2010) emphasised the importance of having a good understanding of the work of control room operators.

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Birger Sevaldson is a Professor at the Oslo School of Architecture and Design. He is a member of the OCEAN design research association. He is trained as an interior architect and furniture designer, and has practiced in various fields of design, including architecture and interior design, furniture design, industrial design, and art based projects. He has a PhD in creative design computing, and has been researching systems thinking in design for the last ten years. His work centers on the development of Systems Oriented Design, and his research focuses on developing systems oriented design thinking and practice for meeting the increased challenges of globalisation and the need for sustainability. He publishes on various themes including Systems Oriented Design, creativity, and research by design.

Systems Thinking

Given the complex nature of the offshore field and the level of insight needed in offshore-specific design projects, it is natural to think that systems thinking could be of value to designers entering this field. Systems thinking involves a holistic view of the world and a consideration of parts as components of a whole—that is, the *system*.

Characteristics of Systems Thinking

Systems thinking evolved as an alternative to the dominant "mechanistic" view of the world, which sees the material universe as a machine, and holds that all aspects of complex structures can be understood by reducing them to their smallest parts (Capra & Luisi, 2014). Throughout the twentieth century several systems theories and approaches were developed. Systems thinking is therefore not one single theory or approach but rather a conglomerate of theories and approaches. Some competing systems theories and approaches exist, while others, such as Critical Systems Thinking, propose an eclectic approach where methods from different systems approaches are chosen based on the nature of the problem at hand (e.g., Jackson, 2003; Midgley, 2000). Despite the diversity of types of systems thinking, there are some common characteristics that distinguish systems thinking from the traditional mechanistic worldview. First and foremost, systems thinking implies a shift of perspectives *from the parts to the whole* and *from objects to relationships* (Capra & Luisi, 2014). The components are still important, but systems thinking stresses the importance of the relationships and the emergent properties that follow from the pattern or structure formed by the relationships: "The whole is greater than the sum of its parts" (pointed out already by Aristotle in his Metaphysics [Aristotle, 350 B.C.E.], and also formulated by Hegel in the 18th century in his statements concerning the nature of systems [Skyttner, 2005, pp. 49-50]).

Given that relationships cannot be measured and weighed, as is the ideal of the mechanistic tradition, systems thinking also implies a shift *from measuring to mapping* (and modelling) (Capra & Luisi, 2014). The purpose of a model is to organise, clarify, and unify knowledge in order to give people a better understanding of a system (Forrester, 1991). "Models are ideas about the world—how it might be organized and how it might work. Models describe relationships: parts that make up wholes; structures that bind them; and how parts behave in relation to one another" (Dubberly, 2009, p. 54). Mapping and modelling can be based on mathematical equations, as in Complexity Science (Holland, 2014), System Dynamics (Forrester, 1991), and Cybernetics (Ashby, 1956), which all use modelling and simulation to gain insight into nonlinear dynamic systems. Maps and models can also be visual representations of the system, such as Concept Maps (Novak & Cañas, 2008); Rich Pictures, used in Soft Systems Methodology (Checkland & Poulter, 2006); and GIGA-mapping, used in Systems Oriented Design (Sevaldson et al., 2012; Sevaldson, 2013).

Multidisciplinarity and the application of *multiple perspectives* are also inherent in systems thinking (Capra & Luisi, 2014). Considering a phenomena through multiple perspectives is important to gain a rich picture of a situation, because complex phenomena are impossible to understand by "seeing" them from one point only (Nelson & Stolterman, 2012).

The last important aspect of systems thinking emphasised here is *boundary setting*, in which *boundary critique* is a core idea. This involves "judgments as to what 'facts' (observations) and 'norms' (valuation standards) are to be considered relevant, and what others are to be left out, or considered less important" (Ulrich, 2002). Such judgement-making can also be referred to as making *appreciative judgements* (Vickers, 1965). In a design project, boundary setting implies judging what should be in the foreground of the design process and addressed actively, and what is in the background and part of the context. Churchman (1971) used the design of a family home to exemplify how boundaries can be set broadly or narrowly. He suggested that the architect in a narrow manner can choose to address the design of the physical house, with its rooms and floor plans, only. Applying a broader perspective, the architect can choose to consider "whether the house is not a component of a larger system, consisting of the family (or its activities) and the house. When he does ask himself this question, he may wonder whether his design task should include the design of a part of the family's activities" (Churchman, 1971, p. 7). Thus, boundary setting is inherent in making framing judgements used for "defining and embracing the space of potential design outcomes" (Nelson & Stolterman, 2012, p. 148).

Systemic Approaches in Design

The development of the design methods movement in the 1960s, which sought to make design more scientific, was influenced by the systems theories and approaches (Bayazit, 2004; Buchanan, 1992; Cross, 2001). Some claimed, however, that this attempt to incorporate systems thinking into design led to illegitimate simplifications (Bayazit, 2004). In the 1970s, Rittel's introduction of the concept of "wicked problems" (Rittel & Webber, 1973) marked a shift in how design problems were viewed and called for other systemic approaches in design (Jonas, 2005). As design in recent years has increasingly been used to tackle larger and more complex issues, designers have given renewed attention to systems thinking: see, for example, Jonas (2005), Valtonen (2010), Nelson and Stolterman (2012), Sevaldson (2013), and Jones (2014). Jones (2014) proposed systemic design as a common term for these recent attempts to merge systems thinking and design:

> Systemic design is concerned with higher order systems that encompass multiple subsystems. By integrating systems thinking and its methods, systemic design brings human-centered design to complex, multi-stakeholder service systems as those found in industrial networks, transportation, medicine and healthcare. It adapts from known design competencies—form and process reasoning, social and generative research methods, and sketching and visualization practices—to describe, map, propose and reconfigure complex services and systems. (p. 93)

Much of the research into using systemic approaches in design has focussed on designing for societal challenges, such as that of Manzini, Vezzoli, and Clark (2001), who used the concept of Product-Service Systems in designing for sustainability, and Jones (2013), who discussed systemic design-approaches to deal with design issues facing healthcare. The design research community has not addressed the use of systemic approaches when designing for high-risk industrial settings such as the offshore industry to the same extent. Sevaldson et al. (2012) provided examples of how Systems Oriented Design has helped design students embrace and understand the complexity of the offshore industry, while Lurås (2012) has suggested that the design process needs to be rethought using systemic approaches when designing a ship's bridge. Still, more research is needed on this area given the increased use of designers in such areas. To consider if and how systemic approaches are of relevance when designing for the offshore industry, it is necessary to understand both the nature of the design projects carried out in this area and the experiences of designers working for the industry.

Research Method

An interview study was carried out to meet the research objectives of this article. The Norwegian offshore industry was chosen as a prime example of a field that designers perceive as being complex and unfamiliar, but one in which designers are increasingly being hired. Qualitative research interviewing was chosen as a research method because it allows interviewees to share their experiences and understanding of their world, and because it facilitates mutual knowledge construction between the interviewer and the interviewee (Kvale, 2007).

Data Collection

We conducted research interviews with eight professional industrial and interaction designers. The interviews lasted 1 - 1 1/2 hours, and were based on a semi-structured interview guide (Kvale & Brinkmann, 2009). A semi-structured interview resembles a conversation and centres around predefined topics. The interview guide of this study was developed around a narrative where a specific project that the interviewed designers had worked on was used as the starting point. The topics of the interview guide included the following:

- The designer's general experience with designing for the offshore industry;
- How projects for the offshore industry differ from other design projects;
- The challenges designers face in offshore-specific design projects;
- The design process, methods, and techniques applied in the projects;
- The designer's role and relationship with people from other professions in the projects;
- The designer's skills that were considered important in this kind of project;
- The designer's dream project for the offshore industry.

The interviews were conducted from May to June 2013. All interviews were audio recorded and transcribed in Norwegian. Quotes used in this article have been translated into English by the researchers, and the translations have been approved by the designers who made the statements.

Sampling

The sampling for the study aimed to find people with relevant experience. We wanted diversity, yet with some common background to enable comparison across the interviews. Thus, our sampling criteria were that the participants should have a master's or similar degree in industrial design and should have had at least two years of experience working in the offshore industry. They should also have had experience in other fields. Further, the participants had to work at design consultancies that serve the offshore industry or as in-house designers at equipment suppliers. To ensure diversity, we wanted designers working at different workplaces; in total, six design offices / equipment suppliers are represented in the interviews. Given that the use of designers in the Norwegian offshore industry has been limited until recent years, it was a challenge to find potential interviewees with more than ten years' experience in this field. As Table 1 shows, the participants had from two to more than twenty years of experience as designers at the time of the interviews, and they had from two to ten years of experience with designing for the offshore industry. The interview study has been approved by the Data Protection Official for Research in Norway and informed consent was obtained from all participants.

There are no general recommendations for the sample size in qualitative research interviews (Guest, Bunce, & Johnson, 2006; Marshall, Cardon, Poddar, & Fontenot, 2013). Some propose purposive sampling and suggest that one should stop interviewing when "theoretical saturation" is reached (e.g., Coyne, 1997; Miles & Huberman, 1994). A more general notion of data saturation are proposed by some and described as the point in data collection and analysis when further interviewing gives no new information (e.g., Guest et al., 2006). In our case, with a fairly homogeneous group of participants, we gained little new insight after six interviews, and decided to stop interviewing after having conducted eight interviews.

Table 1. Profiles of the designers interviewed.

ID	*Design field*	*Total years of experience*	*Years of experience in offshore industry*
D1	Industrial and interaction design	10	**10**
D2	Industrial and interaction design	8	**8**
D3	Industrial design	8	**8**
D4	Industrial and interaction design	9	**9**
D5	Industrial design	>20	**2**
D6	Industrial design	8	**8**
D7	Interaction design	2	**2**
D8	Interaction design	5	**3**

Data Analysis and Interpretation

The interview analysis focussed on meaning interpretation, where we sought to go beyond what was said directly and tried to identify meaning that was not immediately apparent. We used systems thinking in our analysis, which meant that we did not merely reduce the interview data to "meaning units" that were individually analysed, but that the different meaning units were also considered in relation to the rest of the interview data. We also viewed the issues that came to light in the interviews as reflecting a wider context, and drew from our own experience. This experience involves, in addition to several years of research on and design for offshore and other complex settings, an ongoing practice-based design research project addressing the design of a ship's bridge ("Ulstein Bridge Concept," n.d.).

The interpretation of the interview data was carried out at several levels, as suggested by Kvale and Brinkmann (2009). A first interpretation was made together with the interviewee as part of the interview. Immediately following the interview, a second interpretation was carried out by the researcher who had conducted the interview. After the interviews had been transcribed and anonymised, the transcriptions were shared with the other two researchers. Before meeting to discuss the interviews, each researcher interpreted the interviews individually. A more formal analysis was also conducted using coding of the transcriptions, which is a way of defining what the data are about and easing the analytical process across several cases (Gibbs, 2007). The topics used for coding were partly defined before the interviews were conducted, based on the aims of the study and the interview guide, and partly developed inductively while going through the interview data. To assign codes and develop additional codes, we first performed "meaning condensation" on three of the interviews, which involves rephrasing the meanings expressed by the interviewees into shorter formulations and meaning units; based on these condensed meaning units, we then identified central themes that could be transformed into thematic codes (Kvale & Brinkmann, 2009). This resulted in forty-nine thematic codes which were categorised into the following groups: the industry, the projects, client relationship, challenges, designers' role, strategies and approaches, complexity and systems thinking, insight, user involvement, focus in the design process, design practice, collaboration with other disciplines, and other framework conditions. All eight interviews were coded using the QDA Miner Lite software.

The final interpretation of the data focussed on identifying relations and patterns based on the coded meaning units across the interviews and considering the findings in relation to the objectives of the study. This interpretation relied heavily on synthesis, using different clustering and visualisation techniques. Figure 2 shows the final map developed to understand the relationships between the challenges the designers faced when seeking to develop "adequate designs" (Nelson & Stolterman, 2012, p. 99). Other visualisation techniques were used for other parts of the data analysis.

Validity

Validity in qualitative research implies that what is reported is a credible description of the phenomena studied (Lützhöft, Nyce, & Petersen, 2010). Throughout the interviews, we validated our understanding by summarising our interpretation of what was said and giving the interviewees the opportunity to come forward with corrections. The final results were validated by giving the interviewees the possibility of reading through a draft version of the article and giving their feedback.

In the analysis, validity was increased by the fact that all three researchers interpreted the interviews individually before we discussed the results as a group. The final results were validated by having a colleague not involved in the study go through all the anonymised transcriptions and then assess whether or not the final article reflected the interview data.

Results

Based on our analysis of the interviews, we divide the main findings of the study into: 1) characteristics of offshore-specific design projects, 2) challenges in designing for the Norwegian offshore industry, and 3) the designers' strategies for addressing the challenges.

Characteristics of Offshore-Specific Design Projects

A typical design project for the offshore industry involves developing products based on highly advanced technology to be used in complex operations. The term "product" here includes both physical and digital products. Projects that the interviewees have conducted for this industry include interaction design of sensor technologies, charts, positioning systems, radar systems, and communication and automation systems, as well as interaction and industrial design of consoles and operator chairs. Most of the products designed are highly interactive, although some of the design projects discussed involve products that are less often operated by human beings, such as component parts of the onboard machinery on ships or rigs. A couple of examples where the designer was involved in the client's strategy-setting were also discussed in the interviews.

When asked whether design projects for the offshore industry differ from generic design projects, all the interviewed designers stated that there was a clear difference. By "generic design" projects, we mean the type of projects for which industrial designers are traditionally trained in Norwegian design schools. For industrial design, this could be mass-produced consumer products, such as furniture or consumer electronics. Examples from interaction design include websites, application software, and mobile apps.

The designers used several ways to describe the differences, as shown in Table 2. One of the designers stated that the most important difference was whether or not one was designing for professional users, who will use the product to perform work-related tasks. He saw little difference in designing a product to support, for example, accountants and designing products for deck officers onboard a ship. In both cases, his experience was that there were many stakeholders, that the designer was normally unfamiliar with the field and user tasks, and that there was often a great deal of complex data that needed to be understood by the designer. Another designer made an important distinction between designing "lifestyle products" that are developed to meet the emotional needs of users and designing "critical products" that are developed to fulfil functional needs for industrial settings. Several designers said that it is common to focus on functionality and technology in the offshore industry, and that the design profession's traditional focus on aesthetics and the users' emotional experiences of a product are paid little attention in this industry. Another distinguishing factor the interviewees suggested was the difference in potential consequences when bad design resulted in erroneous use. One designer pointed out that the consequences of a bad design in the offshore industry can be catastrophic, using the Deepwater Horizon disaster as an example, while the consequences of a bad design in consumer products can be serious yet rarely will affect more than the individuals involved. Other factors mentioned were that the products of the offshore industry are designed for a business-to-business market, which means that the end-user is not the one making the purchase decisions; that offshore products may be more complex and more technically advanced than consumer products; and that the offshore industry is highly regulated.

Challenges in Designing for the Norwegian Offshore Industry

While the designers interviewed had all been involved in successful design projects for the Norwegian offshore industry, they still reported that they faced challenges when working in this area. Figure 2 presents a visual map of the challenges they mentioned that add to the complexity of designing for this field.

Table 2. Differences between designing for the offshore industry and generic design projects, as suggested in the interviews.

Generic design projects	*Design projects specific to the offshore industry*
Fewer stakeholders and fewer factors to consider than offshore-specific design projects	Projects with many stakeholders and different goals involved; contradictory factors to consider
May involve design for both non-professional and professional users	Design for professional users who use the product to carry out work-related tasks
Design objects are often lifestyle products fulfilling emotional needs of individuals	Design objects are critical products developed to fulfil functional needs in the industry
Greater focus on aesthetics and emotional factors	Greater focus on functionality and technical factors
The consequences of a bad design can influence individuals negatively, but will seldom be catastrophic	Safety-critical products used in high-risk contexts; the consequences of bad designs can be catastrophic
Design for the consumer market, where the end-user is often involved in the purchase decision	Design for business-to-business markets where the end-user usually is not making the purchase decisions
Can be technically advanced, but normally to a more limited degree than offshore projects	Products usually highly technically advanced
Sources of insight on use often easily accessible	Sources of insight on use difficult to access
Normally not as highly regulated by legislation, rules, and standards as offshore-specific design projects	Highly regulated by legislation, rules, and standards

These challenges make it difficult to achieve designers' goals to "develop adequate designs"—that is, the best possible design within the time and resources available (Nelson & Stolterman, 2012, p. 99). The placement of the individual challenges on the vertical axis of Figure 2 suggests whether it is an industry-specific challenge or a project- and design-specific challenge. The challenges emphasised in **bold** were those stressed the most in the interviews, and the ones with an increased font size were the ones suggested as the most important in our interpretation. The map also suggests relationships between the challenges identified in the analysis of the interviews. One may start reading the map at any point.

Based on what the designers emphasised in the interviews, we have divided the challenges mentioned into: 1) designing for a high-risk domain with a strong focus on safety, 2) barriers to gaining an understanding of the systems, 3) grasping the volume of information needed to gain insight, and 4) working broadly and holistically.

Designing for a High-risk Domain with a Strong Focus on Safety

One important characteristic of the offshore industry is that it is a high-risk domain where the consequences of an accident can be catastrophic. There is thus a strong focus on safety in this industry. The designers interviewed stressed that this makes it particularly important to gain insights into the users and context of use, and several stated that they would not take on projects where there was no potential for gaining that insight. The necessary insight as described in the interviews is both related to the domain and project organisation—which we refer to as the system one designs *within*—and the system one designs *for*, which covers the operation for which to design, the context of use, and user tasks. The system one designs *within* influences the possibilities in designing the product for the system one designs *for*. As shown in the upper left quadrant of Figure 2, our interpretation is that understanding these partly overlapping systems involves: 1) understanding the industry; 2) understanding the operation and context in which the designed product will be used; 3) understanding the actors involved (both the users and other actors involved in the operation itself, as well as other stakeholders in the development process); 4) understanding the functions and tasks the product supports; and 5) understanding the technology and functionality involved.

The fact that the offshore industry is a high-risk domain with a strong focus on safety has resulted in the industry being highly regulated by legislation, rules, and standards. These regulations often prescribe specific design solutions, and some of the designers interviewed saw them as limiting factors that narrowed the space for possible solutions. This, they said, adds to the difficulty of developing novel designs. In order not to increase the risk level, there is a demand for proof that a new design is as good as, or better than, the old design. As one of the designers interviewed said, "To say 'I just feel this is right' does not hold in these industries" (D4 #00:36:06-8#). The requirements for evidence can make some designers reluctant to think beyond the known, and makes it difficult to maintain what one designer referred to as "the magic of design." Several of the designers stated, however, that they considered getting the design approved by regulatory bodies to be the responsibility of the client, not the designer.

The regulations were not viewed as a detrimental restriction by all of the interviewed designers, however. One designer saw the requirements as something that designers were obliged to question, and as a starting point for creativity. In his opinion, designers need to understand the purposes of the requirements and consider whether there are other ways of achieving these same purposes. The regulators develop requirements based on what exists, and if designers do not question the existing solutions, he feared that there would be no development or change for the better. Studies in design expertise have shown that other expert designers have similar approaches to the role of regulations in a design project, as for example the Formula One car designer Gordon Murray (Cross, 2011). Still, no matter how the designer treats the regulations, they are a framework condition that adds to the complexity of projects.

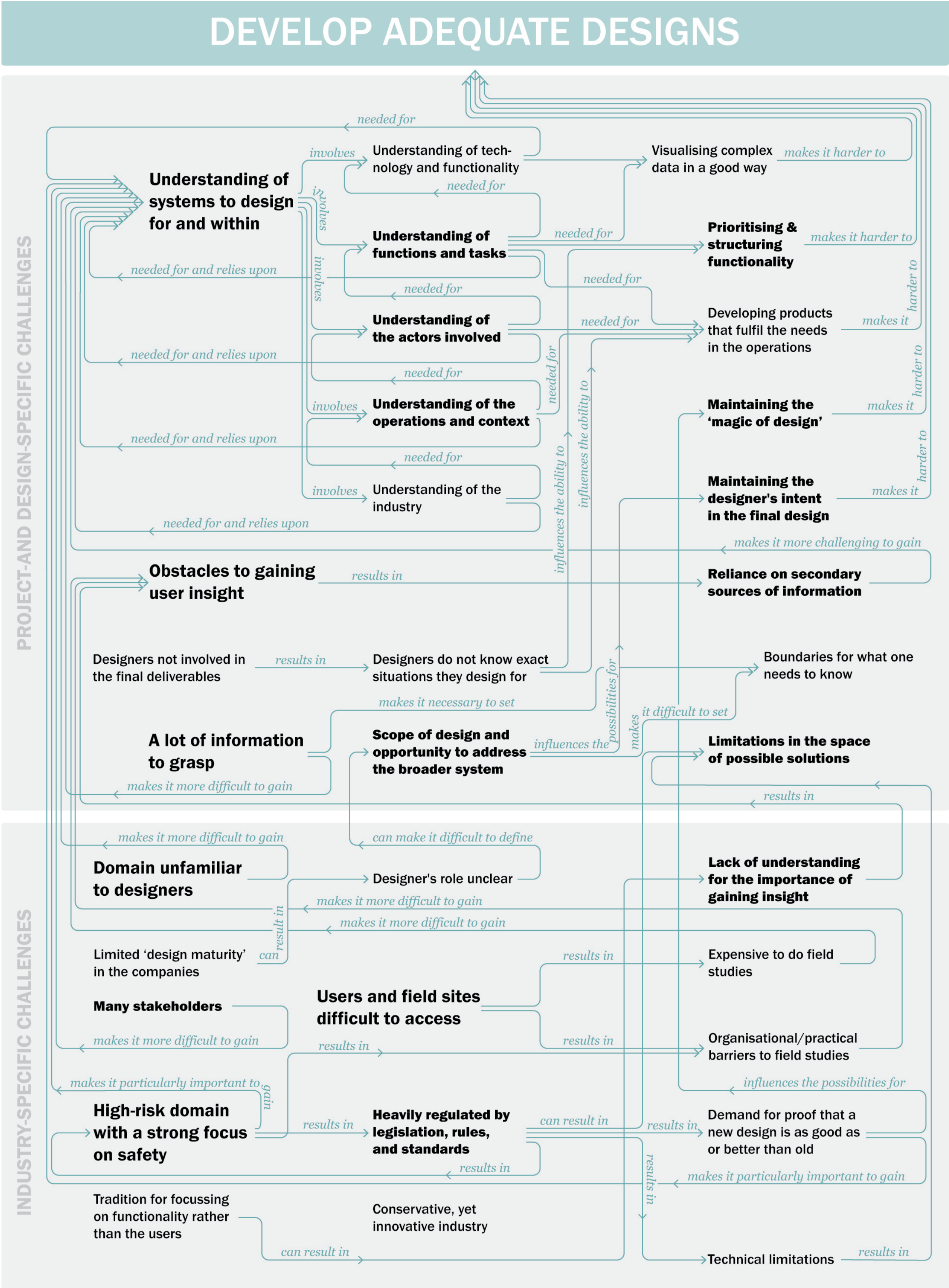

Figure 2. The challenges designers faced in the offshore industry, as described in the interviews.

Barriers to Gaining an Understanding of the Systems

As Figure 2 illustrates, many of the challenges mentioned in the interviews are related to understanding the systems to design *for* and *within*: either because the suggested challenge makes it particularly important to understand the systems to design for and within, or because they are barriers that make it more difficult to gain the necessary understanding of the project. One challenge that adds to the difficulties is that the field is normally unfamiliar to designers. Of the eight designers interviewed, no one had experience in the offshore industry before they first became engaged as designers. Thus, the designers stressed that visiting the field sites and observing the product in use was necessary in these projects. As one of the designers interviewed said, "Seafarers' brains work differently than a landlubber's. Seafarers know instinctively the heading of the ship and which way is north. Such dimensions are difficult to pick up without being at sea" (D4 #00:12:53-3#).

Several of the designers, however, emphasised that gaining access to users and field sites was a major challenge. Only three of the designers interviewed had taken part in field studies offshore. As shown in Figure 2, the industry-specific challenge "Users and field sites difficult to access" results in other challenges. One major challenge is that doing field studies becomes expensive: and in the experience of the designers, this is a cost that many clients are not prepared to accept. Other challenges are of a more practical nature, such as that the opportunity for joining a vessel can be unpredictable and that it may not always be possible for the designers to go when such an opportunity arises. The designers also described how the location of the field sites, together with the industry's focus on safety, introduces organisational barriers to conducting field research. In some cases, certain safety certificates are required; in other cases, the contractor operating the vessel or rig needs to obtain approval from the oil company in order to bring designers aboard. When designing for the offshore industry, one may also experience the challenge of designing for extremely rare situations that are almost impossible to observe. One of the designers gave an example from one of his projects: "An oil spill at sea occurs once a year. The few beds on a vessel going out when a spill has happened are highly coveted and needed by others" (D4 #00:10:36-9#). As indicated in Figure 2, the challenges related to gaining access to users and field sites makes it more difficult to gain an understanding of the systems to design for and within.

All of the designers interviewed had experienced challenges to doing field studies and also to meeting users onshore. As one designer put it, "It is incredible how difficult it has proved to do what you thought, while being a student and a fresh designer, was the most important part of a project, and the most natural thing to do as a designer" (D8 #00:46:41-8#). In many projects this had forced the designer to rely on secondary sources of information, which may include people such as clients who are familiar with the field, or written material and online media. Figure 3 shows the different situations the designers interviewed experienced when seeking to understand the user (U) and the context of use (C). In the ideal situation (a), the designer had direct access to users and the context. In the less desirable situation (b), the designer had access to users onshore but needed to learn about the context through the users or other secondary sources. In the least desirable—but not uncommon, according to the designers—situation (c), the designer needed to learn about both the users and the context of use through secondary sources.

Grasping the Volume of Information Needed to Gain Insight

No matter if one gets direct access to users and the context of use or must rely on secondary sources of information, the information available about the systems to design for and within is fragmented and the amount of information substantial. The designers interviewed described how grasping the volume of information can be both challenging and time-consuming. One of the designers suggested that a designer new to the field needs about six months before getting a grip on what the industry is about. This implies that being patient and persistent are important qualities for a designer in this field.

As indicated in Figure 2, the challenge "A lot of information to grasp" makes it necessary to set boundaries for what one needs to know. One of the interviewed designers stated, "I do not think we ever will reach the stage where we understand everything. This is such a big world, and you have to focus on grasping just what is relevant to what you are supposed to do" (D8 #00:24:47-6#). The

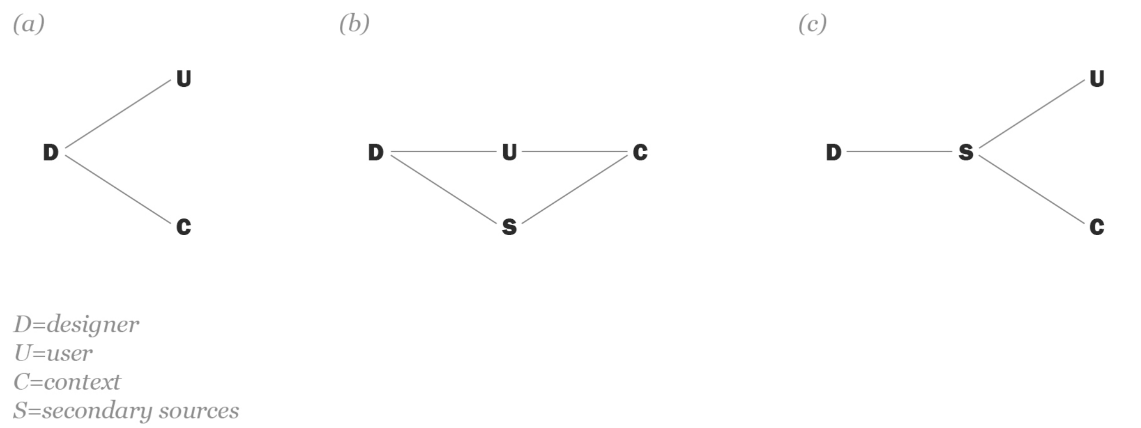

Figure 3. Designers' access to users and context of use.

challenge of grasping the volume of information makes it more challenging to gain the necessary understanding of the systems to design for and within.

Working Broadly and Holistically

The offshore industry has traditionally developed products without involving industrial and interaction designers. As shown in the lower left quadrant of Figure 2, the designers have experienced "Limited 'design maturity' in the companies" of the offshore industry. This challenge can lead to the designer's role being unclear, which can make it difficult to define the scope of the design project. This can limit the designer's opportunity to address the broader system. The designers interviewed described that this challenge can make it difficult to set boundaries for what one needs to know as a designer, and may influence the designers' possibilities for maintaining his or her intent in the final design.

As designers do not have an established role in this field, the designer's role in the projects addressed in the interviews varied. The designers described sometimes being hired to perform a specific predefined task, such as to redesign a piece of equipment or a user interface. Other times they were hired because of their competence, provided with a less well-defined brief, and given the role of the driver of the development process. This is similar to a role of the designer as *collaborator*, which results in a situation where "both the client and the designer mutually work on framing the project in terms of both problem and solution spaces" (Paton & Dorst, 2011, p. 579). Such a role was identified as the most desirable by many of the interviewees. They indicated, however, that there were many reasons why designers rarely got this kind of role in the offshore industry.

The level in the client's organisation at which the design project is run influences the designer's role. In some of the projects discussed, the designers reported to top-level management. In most of the projects, though, the designers were involved only in the development of specific products and were hired at a lower level in the client organisation, such as by a product development department.

The client's role in the industry's "ecosystem" also affects the scope of the design project and the designer's role. In many cases, the client is an equipment supplier with little opportunity to influence the whole working environment their products will be part of. When suppliers are involved in concrete deliverables and may influence the whole, the designers interviewed had not been involved. The fact that designers are normally not involved in delivery projects means that the product they design will be used in a variety of configurations, on different types of ships or rigs, and sometimes can be used for different purposes. As indicated in Figure 2, this introduces further design challenges, such as that it can be more difficult to prioritise functionality in the detailed design.

The designers interviewed would like to be involved more often in framing the projects, and all stated that they would like the opportunity to work more holistically, even though they varied on where they drew the line in relation to thinking holistically. While one designer drew the line within the client's organisation and suggested being able to address the total product portfolio of the client, another dreamed of being able to question more fundamental issues, such as which mode of transportation to use for transporting cargo between onshore and offshore.

The Designers' Strategies for Addressing the Challenges

Through the interviews we saw that the designers employed different strategies for coping with the challenges experienced when designing for the offshore industry. The strategies they described are related to 1) strategies for gaining insight, and 2) strategies for boundary setting.

Strategies for Gaining Insight

All the designers interviewed stressed that having an in-depth understanding of the users' tasks and context of use is particularly important when designing for the offshore industry, and that conducting field studies at sea is the best strategy for gaining such an understanding. Access to users and context of use is limited in these projects, however. Those who had conducted field studies placed great emphasis on the insights that they gained from this but also stressed that one trip at sea does not make one an expert. Thus, both those designers who had done field studies and those who had not described a diverse range of alternative ways to gain the needed insight throughout a project, including interviewing, conducting sessions with users, and observing training sessions onshore when access to users was granted; and, when gaining access to users was more difficult, reading documentation such as industry standards and accessing material shared by users through social media. Some of the designers stressed that using scenario methods in sessions with users is a successful way to gain a deeper understanding of the system to design for.

A couple of the designers described how they use designing to gain insight. One designer emphasised how one does not always need a thorough understanding of the situation to make the first sketch: a lot can be developed based on good design practice and previous experience. Another designer explained how he starts designing early, based on gut feelings and with very little insight, and then uses these first designs as starting points for discussion with users. The designer repeats these user sessions as often as possible throughout the design process. Through this approach, this designer said he more quickly gains better quality insights, and reaches a good design solution earlier. This is preferable to the traditional design process he described, where the designer first conducts an insight phase, and only then develops designs. "Insight is not a phase," he stressed throughout the interview. A significant body of research indicates that developing solutions to understanding a problem is a common strategy among expert designers (Cross, 2004).

Several of the designers interviewed stressed that structured and analytical approaches are needed in order to grasp all the information necessary for understanding the system one designs for and within. "The somewhat unstructured artist-like designer will not necessarily be right for these professional settings. When designing for these environments, the designers have to be able to structure large amounts of information and delve deep into functionality. They need to understand the everyday lives of users within a domain that they have no previous knowledge of. This simply doesn't suit every designer" (D1 #01:00:54-4#). None of the designers interviewed described particular methods for handling the large amount of information they needed to grasp, although several stressed that strategies for filtering and structuring the information were necessary. When asked specifically whether they used systemic approaches as an aid for this, none confirmed that they had consciously done that, even though some of them described using systemic approaches, such as scenarios and different activity mapping techniques.

Strategies for Boundary Setting

The designers interviewed acknowledged that due to the complexity of offshore-specific design projects, one cannot fully understand the systems to design for and within. Thus, the designers have to set boundaries for what is within the scope of the design project and what is not. The designers had different approaches to this. One designer put it this way: "The strategy is rather to understand what you don't need to understand" (D3 #00:24:08-3#). Another interviewee said that a designer should pay close attention to what the client specifically mentions in meetings, and that what is not mentioned is of lesser importance. Yet another designer stressed that in these kinds of projects, the designer needs to "accept functionality"—that is, to accept that there are certain functions that are set and cannot be changed. This designer's approach was to identify what was possible to alter and what needed to be considered as fundamental. Nelson and Stolterman (2012) claim that the skill of making such appreciative judgements is fundamental to design judgements.

In one of the interviews a good example of how a different approach to boundary setting proved valuable in a project was brought up: The office of the designer interviewed helped a client develop a new system to be used for oil spill detection on offshore service vessels. Using scenarios to gain a deeper understanding of the operational context and the users' tasks, they quickly realised that the greatest advantage of the product would be if several vessels could use it to collaborate in a network. Rather than attempting to start with the whole network, however, they started with designing a really good operator station to be used onboard one vessel. Once that was in place, they addressed the broader system. "You have to start with something that is very focussed, something that is based on clear needs. But as a designer, you must also have the ability to look ahead and create solutions that one can grow into, and not grow out of" (D4 #00:20:08-2#). This way, the product evolved from being a tool enabling an individual user to detect an oil spill to becoming a system of collaboration for oil spill response including many ships, a lot of people, and completely new ways of handling oil spills.

Through the interviews we have gained an understanding of the characteristics of offshore-specific design projects and how the designers interviewed experienced designing for this industry. Now it is appropriate to ask: Could systemic approaches that have proven valuable when designing for other complex issues be relevant and of value when designing for the offshore industry? If so, in which ways can systemic approaches help?

Discussion

The designers interviewed described both the systems they designed *for* and the systems they designed *within* to be highly complex, and that gaining the necessary understanding of these systems can be challenging for several reasons. In the following we will discuss the relevance of systems thinking in offshore-specific design projects in the light of the designers' experience in: 1) coping with complexity, 2) boundary setting, and 3) ensuring a holistic approach. We also discuss the generalisability of the results of our study.

Coping with Complexity

The challenge of coping with complexity and grasping a substantial amount of information is not unique to design projects for the offshore industry. Weick (2004) suggested using the concept of "thrownness" to indicate that designers are thrown into situations characterised by "limited options, unreflective submission, continuous acting, occasional interruption, unquestioned answers, ready-made categories for expression and interpretation, and disjunction between understanding and explanation" (p. 77). He also claimed that "what separates good design from bad design may be determined more by how people deal with the experience of thrownness and interruption than by the substance of the design itself" (p. 74). A similar observation was made by the designer interviewed who claimed that designing for complex domains such as offshore "simply doesn't suit every designer" because these projects require that designers "structure large amounts of information and delve deep into functionality" (D1 #01:00:54-4#).

The designers interviewed said that they were faced with a large volume of information they needed to make sense of to gain the necessary insights, and that getting a grip on the offshore industry is time-consuming. This implies that designers in this field would benefit from more rapid learning processes. Further, the designers interviewed described how the information they got came from many sources and was fragmented. Experience indicates that having taken part in field studies makes it easier to grasp such fragmented information (Lurås & Nordby, 2014), presumably because field research helps the designer develop "ideas in cognitive structure" (often referred to as a frame), which then makes it easier to assimilate new information (Ausubel, 2000). The interviews showed that access to field sites and users was limited, however, and that conducting field research is a major challenge in offshore-specific field studies. Thus, other ways of developing such a frame will prove valuable in these circumstances.

Experiences with recently suggested systemic design techniques imply that systems thinking can help designers grasp more of the problem field than is normally conceived and more quickly gain the insight needed (e.g., Jones, 2014; Sevaldson, 2013). Scenarios and activity mapping techniques, which some of the designers interviewed described using, are examples of systemic approaches valuable in gaining insight and that presumably can help designers develop a frame of reference useful in making sense of new information. We propose that other systemic techniques, such as Rich Pictures (Checkland & Poulter, 2006), Concept Maps (Novak & Cañas, 2008), and GIGA-mapping (Sevaldson et al., 2012; Sevaldson, 2013) could be valuable in offshore-specific design projects in addition to the ones described in the interviews, because they emphasise relationships and help those developing them get a better understanding of how parts of the system are connected and influence each other. While scenarios usually only focus on the system one designs *for*, techniques such as GIGA-mapping can also be used to "create a detailed overview of the landscape in which a design project will play out" (Sevaldson et al., 2012, p. 14)—that is, the system one designs *within*.

Some of the designers interviewed described how they used designing to gain insight. An interesting observation is that the designers' reason for developing and presenting their not-yet-thought-through designs to users and stakeholders early was not only to develop new designs, but also to learn about the current situation. This approach thus had a validation purpose: correcting the designers' interpretation of the system they were designing for. In this sense, early sketches and prototypes serve the purpose of being what Capjon calls "negotiotypes," used to negotiate understanding (Capjon, 2004, p. 292). In a similar manner, system models and maps could be developed early with limited information and used to negotiate understanding. Rather than specifying everything in advance, a map or model of the system can be developed based on what the designer currently knows and assumes, and then be assessed together with users or other stakeholders. Experience from master's-level student projects suggests that GIGA-mapping can serve such a purpose and work "as a fundament for communicating ideas and findings and at the same time arguing for decisions made. During this debate various root definitions and conceptual models were put forward, modified, and developed until a desirable model was achieved by consensus" (Sevaldson et al., 2012, p. 19). A strategy of designing early and using preliminary designs to negotiate understanding can help the designers avoid becoming overwhelmed by this system that they describe as impossible to get a complete grip of, and can help them avoid "analysis paralysis."

Nelson and Stolterman (2012) described that framing categories are needed in order to examine and understand systems. None of the designers reported having explicit training in the field of systems thinking, and most were not familiar with the systems vocabulary. To be better prepared for developing system models and maps of value in the offshore-specific design projects, we encourage designers to get an understanding of the core concepts of systems thinking. We propose an eclectic approach to systems thinking, as stressed in Critical Systems Thinking (e.g., Jackson, 2003; Midgley, 2000), and suggest that concepts derived from different systems theories and approaches can be of value to designers. Examples include *connections*, which define how casual power is transferred between things, and *relations*, which define how things compare and contrast with one another (Nelson & Stolterman, 2012), both of which can help the designer identify not only which parts of the system are interconnected but how they influence each other. The concepts of *tightly coupled systems*, in which parts of the system are highly interdependent, and *loosely coupled systems*, where the parts are not very dependent on each other (Perrow, 1999), can help the designer assess the criticality of the different parts of the system, while the concepts of *leverage points* and *systemic interventions* (Meadows, 2009; Midgley, 2000) can prove valuable in considering where in the system making changes will have the greatest impact.

Boundary Setting

The boundary or frame of a design project defines what is part of the system to be addressed by the designers and what is out of their scope. The interview study shows that the boundaries of offshore-specific design projects vary and can be unclear. But the study also shows that the designers to some degree can influence the boundaries of a project, and that different approaches to boundary setting were used by the designers interviewed. When the designers make the client fully responsible for setting the boundaries of the project, we interpret this as employing a passive strategy to boundary setting. The opposite is a *proactive strategy*, where the designers themselves are involved in setting the boundaries of the design project based on what they know about the systems they design for and within. As the project addressing design for oil spill response shows, such a proactive approach can prove valuable.

We believe that one reason why designers apply passive strategies to boundary setting is that designers traditionally are not trained in working consciously with boundaries. Mapping and modelling techniques can be useful in setting the boundaries of a design project for several reasons. They can help designers get a better understanding of the system one designs *within*, which makes it easier to identify what types of changes will be possible in the system one designs *for* and what kinds of designs (interventions) will have a significant impact. These techniques can also help designers gain a better understanding of the systems they design *for*, which may enable the designer to see new opportunities beyond the original task. Such opportunities could result in improvements of the use situation, which for example could contribute to enhanced safety; or it could result in new product ideas, which could then result in business opportunities for the client. In recent years some systemic techniques within design have been proposed that can help the designer in making such judgements, e.g., ZIP-analysis, which is used to find potential areas for interventions and innovations in a system (Sevaldson, 2013).

Ensuring a Holistic Approach

The interviews have shown that offshore-specific design projects involve understanding and balancing multiple perspectives. The complexity of such projects suggests that multidisciplinary development teams are needed. Majer and Rechtin (2009) have pointed to the problem of ensuring a holistic view in complex projects where many disciplines are involved. They suggested a new role responsible for ensuring a holistic approach, parallel to project management: the role of the *systems architect*. The term "architect" refers to architects' assumed ability to handle complex problems in a holistic way.

The designers interviewed believed that designers are well-suited for taking on such a role and being responsible for holistic thinking in the project teams. We propose that systemic approaches, such as visual modelling and mapping, can help designers both to grasp the complexity of the system they design *for* and *within* and to obtain the role they would like in the system they design *within*. Because designers are trained in visualisation they are well qualified for taking responsibility for mapping and modelling tasks of a project. However, the use of designers in the Norwegian offshore domain is relatively new, both to the design profession and to the offshore industry, and a broader study is needed to conclude whether designers really are in a unique position to take on a role similar to a systems architect in such projects.

Generalisability of the Research

According to Flick, "the focus of interview research is (mostly) the individual experience of the participant, which is seen as relevant for understanding the experience of people in a similar situation" (Flick, 2007, p. 79). In qualitative research, the traditional quantitative concept of generalisation is normally not of interest (e.g., Flick, 2007; Kvale & Brinkmann, 2009; Lützhöft et al., 2010). "If we are interested in generalizing, however, we may ask not whether interview findings can be generalized globally, but whether the knowledge produced in a specific interview situation may be transferred to other relevant situations" (Kvale & Brinkmann, 2009, pp. 261-262). Kvale and Brinkmann described different ways to consider the generalisability of qualitative interview studies. Most relevant to the study presented here is considering *analytical generalisation*, which "involves a reasoned judgment about the extent to which the findings of one study can be used as a guide to what might occur in another situation" (Kvale & Brinkmann, 2009, p. 262). By comparing the characteristics of the Norwegian offshore industry identified in this study with characteristics of other fields, we can gain some indications of whether the findings and conclusions of this study are relevant when designing for other complex and unfamiliar fields.

The Norwegian offshore industry is presumably not very different from the offshore industry in other countries. The industry is, to a large degree, global, with many similarities in regulations and the operations carried out. Thus, we assume that designers engaged in the offshore industries in other countries face similar issues and that the research results of our study are therefore of relevance.

Health care is an example of a different field which presumably holds many of the same characteristics as the offshore industry, and where the designer could meet similar challenges. Similar to the offshore industry, the health care field is characterised by many stakeholders, professional users carrying out complex tasks, high-risk contexts of use where human safety is at stake, and an increasing use of technically advanced products. Even though hospitals are not geographically situated in hard-to-reach locations, it can be difficult for designers to gain access to users and the field (such as an operating theatre) due to organisational barriers. The aerospace industry is another example of a field with similar characteristics. Given the similarities between these domains and the offshore industry, we assert that the research results of our study are relevant when designing for these and other similar fields. More research is needed to conclude whether this assumption holds, however.

Conclusion

In this article we have presented an interview study investigating how industrial and interaction designers experience designing for the Norwegian offshore industry, what challenges they face, and the strategies they use for meeting these challenges. The interview study gave us a thorough understanding of designing for the offshore industry, and based on this understanding we have initiated a discussion on *if* and *how* systemic approaches can be of relevance when designing for this field.

The designers interviewed placed emphasis on gaining insight on the users and the context of use, which we refer to as the system one designs *for*, and described a range of approaches used to overcome barriers to gaining such insight. We stress that designers also need techniques to gain an understanding of the system one designs *within*—the domain and project organisation. Understanding both is important because the system one designs within both introduces limiting factors and provides possibilities related to the system one designs for.

Based on experiences from recent developments within systemic design, we propose that systemic approaches such as *mapping and modelling* and *boundary critique* could be valuable in offshore-specific design projects. Maps and models can be used to develop a frame that makes it easier to assimilate new information, and to more quickly gain an in-depth understanding of the systems to design *for* and *within*. They can be developed early and used to negotiate understanding with users and other stakeholders, similar to the strategy of designing a product early in the design process to gain insight. Furthermore, systemic approaches can be useful in employing a *proactive strategy* to boundary setting, which may help the designer see opportunities beyond the original design task given. We propose that such approaches also could help designers to get closer to the roles they would like in the systems they design *within* because it can help them gain a better understanding both of the system they design *for* and the system they design *within*.

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