# Barrier analysis as a design tool in complex safety critical systems

**Johan Blomkvist,** University of Linköping, johbl@ida.liu.se

**Amy Rankin,** University of Linköping

**Daniel Anundi,** Swedish Meteorological and Hydrological Institute

**Stefan Holmlid,** University of Linköping

## Abstract

When constructing or improving large complex systems, design activities help establish the needs and goals of users, deepen the understanding of the system and facilitate ideation of new solutions. When service systems are large, dynamic and complex, the need for thorough design work is especially evident. However, design methods usually strive to describe and design best case scenarios and we argue they lack the perspective of safety needed when working in safety critical systems. In order to gain knowledge on how a perspective of risk and safety can benefit design in a safety critical domain, two different perspectives were adopted through the use of two different methods. The methods were service blueprinting and barrier analysis, adopted from service design and cognitive systems engineering respectively. The methods were implemented during the research phase of a service design project in a home healthcare system in Sweden. Service blueprinting is a method used by service designers to visualise services. Barrier analysis is aimed at identifying and categorizing artefacts and functions that prevent unwanted events from taking place, or that lessen the impact of their consequences. A comparative analysis of the two methods was performed, concluding that barrier analysis has the potential to benefit design work performed in complex and safety critical systems. The potential for barrier analysis to be more tightly integrated into current service design methods is discussed, but more research is needed in order to clarify this matter.

### Keywords

Service blueprint; barrier analysis; Cognitive systems engineering; healthcare; design perspectives; service design

Large and complex human-machine systems (e.g. process industry, power stations, transport systems, healthcare institutions, etc) present great challenges in organizing, developing and maintaining the successful operation of whatever activity is being performed. In developing these kinds of complex systems we think that adopting a design approach and using design thinking is valuable. It helps establish the needs and goals of users, deepen the understanding of the system and facilitate ideation of good solutions. A design approach helps to put people in focus instead of technology or system architecture (Cooper, 1999).

However, when working with complex human-machine systems the aspect of safety often comes into play. Many of these systems are not only complex but also safety critical, i.e. the risk of serious accidents, injury or death is present. While designers generally have a well equipped toolbox of methods and techniques for user research, ideation and valuation we argue that most designers lack tools to help them consider safety aspects of their design suggestions. Safety consideration is something not generally addressed in the standard set of design tools. We suggest that designers need to turn to other disciplines for methods that can add the perspective of safety and risk when working in safety critical environments. In this paper we will present a case study where such an approach was adopted.

## The different perspectives of design and CSE

Formalized methods and techniques used in design work help designers structure their approach to a design case and provide guidelines and step-by-step formulas to best practice work. However, by directing the designer's attention and actions to certain aspects of the design problem a method can also be said to reinforce a perspective or a focus in the design process. Different methods bring different aspects of the situation to the designer's attention, thus making them prioritized in the design work. It has been shown that actively adopting different perspectives in design processes affects the outcome of design work (Hult, Irestig, & Lundberg, 2006). The use of formalized methods can be a way of directing the focus of design work and can add perspectives not otherwise considered by the designer, thus affecting the outcome of his or her work.

The design disciplines, we argue, carry with them a certain kind of perspective that is reflected in the methods and techniques used in design work. Design is about exploring and unfolding a design space, thus finding the best possible solution to a specific situation. The focus in design work is naturally turned to the positive aspects of potential design solutions. It is often about creating beautiful, functional and pleasant objects and experiences. Methods for visualizing and communicating design solutions therefore focus on best case scenarios, which turns the design focus to the aspects that create these best cases. Design methods may address failure and safety, but few have an explicit focus on worst cases. The traditional design communication techniques such as storyboards and scenarios also focus on specific events, putting focus on a small number of all the possible interactions, activities, and events within a system.

Another discipline concerned with complex human-machine systems is Cognitive Systems Engineering (CSE). CSE has its roots in cognitive science and is devoted to studying phenomena that emerge when people use technological artefacts in their work (Hollnagel & Woods, 2005). CSE is a systemic approach used for analyzing, evaluating and designing complex systems, much like systems design, but with a separate set of methods and assumptions. The CSE approach can be broken down into three main concerns (ibid.); (1) how cognitive systems cope with complexity, (2) how to engineer joint cognitive (human and machine) systems and, (3) how the use of artefacts can affect specific work functions. Within CSE a systems approach is adopted. The basic premise of a systems approach is that humans are fallible and errors are to be expected and caused by an "upstream" of systemic factor, a view initially proposed in Perrow's *Normal accident theory* (Perrow, 1984; Reason, 1990). The main assumption is that it is not possible to change human conditions, but it is possible to change the conditions under which humans work (Reason, 2000). Since CSE is devoted to the understanding of how to maintain control in complex environments, the focus of interest is on the prevention of accidents rather than on finding the best solution for situations when everything is working as it should.

There is a significant difference in perspectives between design disciplines and CSE. While design focuses on best-case scenarios, CSE looks at worst-case scenarios and how to prevent them from occurring. We argue that when designers work in complex and safety critical environments, there is a need for a perspective of safety not normally adopted by designers. We also argue that this perspective could be added to design work by the use of methods from CSE. In order to explore this idea further a research project applying methods from both service design and CSE was carried out in a home healthcare setting.

## Methods

In this section we will begin by describing the methods used to model the home healthcare system. Two methods were used, a *service blueprint*, representing the service design perspective, and *barrier analysis*, commonly used within the CSE domain. The case is described in the following section which leads to a review of the results produced by the two methods. This is followed by a discussion of each individual analysis and concluding remarks concerning benefits and limitations of merging the two methods.

### ***Service blueprint***

Service blueprinting is an approach for service innovation and improvement (for a detailed description see Bitner, Ostrom, & Morgan (2008)). Together with customer journeys, it is commonly used by service designers as a way to visualize services, in order to make them more tangible and susceptible to design activities (Segelström, 2009). A service blueprint provides a description of the service process, customer points of contact and physical evidence as well as the underlying support processes that support and drive the service. Bitner et al. (2008) has described services as "co-created with customers" with examples like; professional services, retail, financial, telecommunication, healthcare, and many others. The original blueprint method was developed in a service management context, and has been adjusted by the service design research community to better fit design activities and goals (Polaine, 2009; Wreiner et al., 2009; Sparagen & Chan, 2008). In this study, the method described by Bitner et al. (2008), has primarily been used, but some changes had to be made to fit the context.

The first step in service blueprinting is to identify and map the process (Bitner et al., 2008; Shostack, 1984). Viewing a service as a process allows the unfolding events to be visualized over time, connected by a number of touchpoints where customers interact with the service. Each touchpoint is subsequently described using five layers; (1) customer actions, (2) onstage, (3) backstage, (4) support processes and (5) physical evidence. When visualizing the blueprint these layers are separated by lines, which allow an illustration of the different interactions over time (see Figure 1). Vertical lines between the components show inter-functional connections between components.

Customer actions include all steps taken by a customer throughout the service delivery process, and are depicted chronologically. Onstage refers to the visible contact made between a customer and an employee, this point is also commonly referred to as a moment of truth. Backstage refers to actions performed by the employee not visible to the customer, for example a telephone call or some other preparation. The fourth layer in the service blueprint is the support processes, which includes all activities executed by individuals who do not have direct contact with the customer but that need to occur in order for the service to be delivered. The last layer, physical evidence, is described at the top of the blueprint and represents all the tangibles that customers come in contact with. The physical evidences are identified for each customer action and every moment of truth. (Bitner et al., 2008)

### ***Barrier analysis***

The second method applied to the collected data was a barrier analysis. Identifying barriers is common within risk and safety assessments in CSE. A barrier is an obstruction or hindrance (or defence) that may prevent or lessen the impact of an unwanted consequence (Hollnagel, 1999). This may include stopping, slowing down, restricting, limiting or in some other way weakening an uncontrollable process. The concept of barriers is used to understand and prevent accidents. If an accident has taken place this means that one or several barriers have failed, i.e. did not serve their purpose or were missing (Hollnagel, 1999). Barrier analysis is frequently used to describe accidents in terms of conditions that lead to failed barriers (Hollnagel, 2004).

Often barriers are identified together with other risk analysis methods in order to provide a context to better understand the barriers' function and how they are related to each other (e.g. Guldenmund et al., 2005; Harms-Ringdahl, 2003; Svenson, 1991). However, in this analysis, barriers were identified directly after the participatory observations and later in the light of the blueprint. To verify that the barriers usage had been correctly interpreted and that no major barriers had been unidentified, several workgroup representatives within the home care service systems participated in a workshop where these barriers were discussed.

## **Barrier systems and barrier functions**

The barrier identification performed on the data collected from observations at healthcare centers included four different types of barrier systems described by Hollnagel (1999, 2004): material, functional, symbolic and incorporeal (immaterial).

- *Material barriers* are physical hindrances, for example buildings, walls, fences, railings, cages or gates. A material barrier does not need to be perceived or interpreted to serve its purpose.
- *Functional barriers* prevent or hinder actions by setting up a number of pre-conditions that need to be met in order for an action to be carried out. This may for example be locks, passwords, distances or delays. The pre-conditions do not necessarily need to be seen or interpreted by a human; they can also be sensed by the system itself.
- *Symbolic barriers* require an act of interpretation by an intelligent agent that responds or reacts to it. Examples are for instance coding (color, shape, spatial layout), instructions, procedures, signs or an approval of some sort. A symbolic barrier indicates a certain limitation but does not in itself hinder an event from taking place, if it is neglected or ignored by the user.
- *Incorporeal barriers* are not physically present in the current situation; they depend on the knowledge of the user. Common incorporeal barriers are rules, guidelines, restrictions and laws.

Barriers can also be categorized according to their function within the system, defined as a specific manner by which the barrier achieves its purpose, the most basic distinction being preventative or protective (see Table 1). As the name implies the function of a preventative barrier is to prevent an unwanted event from taking place. The role of the protective barrier is to lessen the impact of an unwanted effect or action when it has taken place (Hollnagel, 2004).

## Case study

We applied the two methods on a case which covered the early research phase of a design process, and the goal was to use the findings from this research phase to create a model of the complex service system of home healthcare. This model, or description, is the foundation for further design work to find new solutions and improvements. The research group consisted persons with experience in design research, as well as persons with experience of adopting a CSE-perspective in safety critical environments.

### *Data collection*

Initially a literature study of the home healthcare domain was performed (Hägglund & Lind, 2006; Orre, 2009; Wallqvist, 2003; Winge, 2007). Then a total of 25 hours of participatory observations with different care giving organizations was performed by the four researchers. Observations were not only performed in the patient's homes but also at district care centers and at the main hospital in order to gain insight into the workflow of the major organizations participating in the home healthcare system. During the observations, special attention was given to the handling and distribution of medication.

Personnel working within the healthcare system in Sweden are required to report incidents deviating from normal procedure or events that have led to or could lead to injury for the patient. In order to gain insight into issues regarding patient safety within the home healthcare system an initial study of reported adverse events from 2003 to 2009 from several care giving organizations was performed. One of the most common occurrences reported was incorrect handling of medication. This included patients receiving the wrong type of medication, patients receiving medication at the wrong time or medication not given at all.

Within the home healthcare system individual accommodation is necessary in order to meet the patients' varying needs. To preserve our impressions from the observations and to turn our data into a more living individual, we created a persona (Pruitt & Adlin, 2006).

**Persona**

Anja, 85 years of age, has lived alone in her apartment since her husband passed away a few years earlier. Anja is treated for age related diabetes, pain in her hip and occasional depression. She has previously had thrombosis and heart related problems which she takes medication for. Her condition requires the involvement and coordination of a number of care givers, including relatives, home care service, food delivery service, the district care center and the hospital. This means that she gets home visits at least twice a day but often more. Anja was used as a representative of our main user group in the subsequent analysis.

## Results

The results are presented individually for the two methods. A suggestion for how to combine the results is provided in the discussion, followed by the conclusions of this work.

### *Blueprint result*

The service process described in the blueprint analysis was "a typical day in the life of Anja" and included a 24 hour time period. During this day Anja got five visits; three from the home healthcare service, one food delivery and a visit from the hospital. Anja also has an alarm if she needs any help during the evening or night. Figure 1 presents an excerpt from the blueprint. The excerpt shows a period in the middle of Anja's day when a person from the home healthcare service visits to administer medication. The excerpt ends before the caregiver leaves.

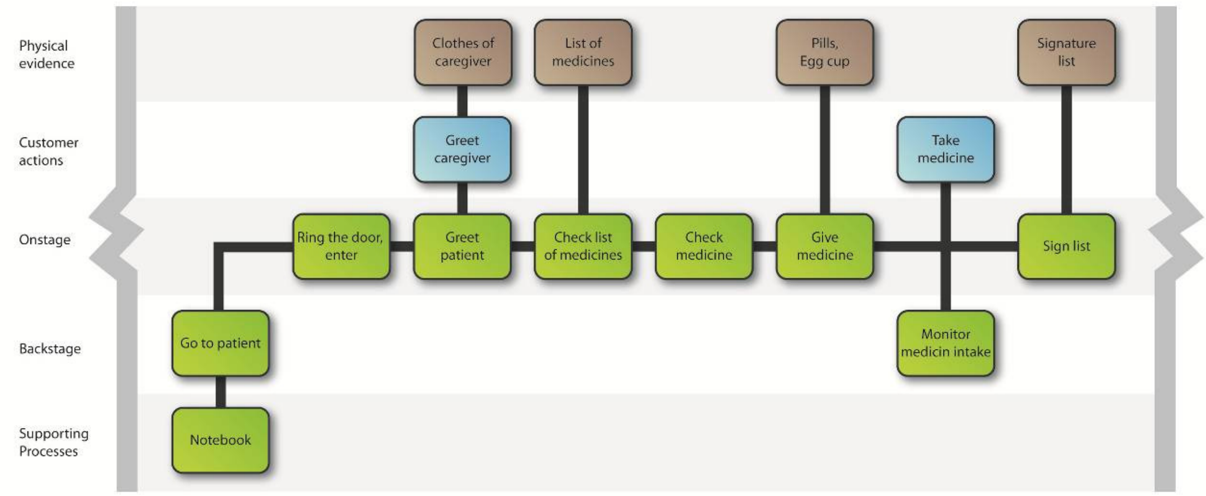



Fig 1. Excerpt from blueprint for home healthcare visit with Anja

### *Barrier analysis result*

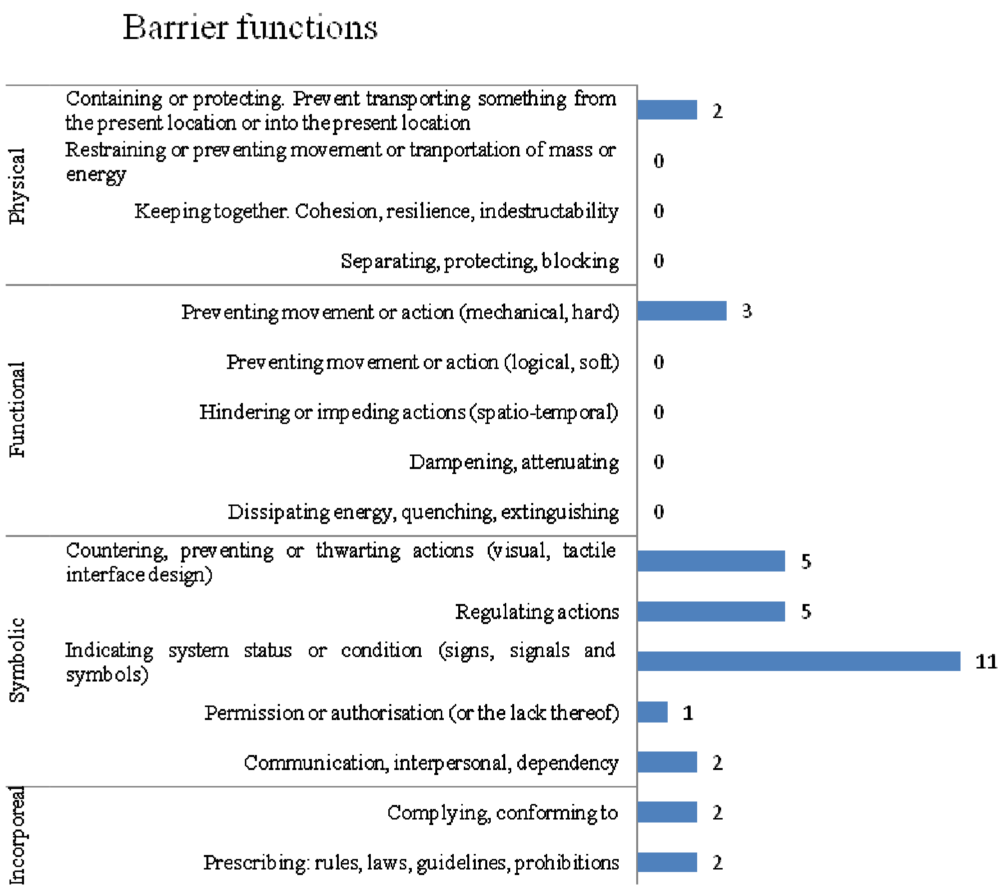
Table 1 and Table 2 show the results of the barrier analysis, note that only barriers relating to medication have been identified in the system. In Figure 1 the barriers are identified as well as the barrier system they belong to and if their function is preventative (Pre) or protective (Pro). Table 2 presents a more detailed description of the barrier functions and their distribution; the numbers in Table 1 correspond to the functions in Table 2. For example "egg-cup" and "medicine cabinet" are physical barrier systems, classified as category 1 in Table 1. This corresponds to "Containing or protecting, prevent transporting something from the present location or into the present location" in Table 2.

Table 1. Barrier systems and barrier functions in a home healthcare system in Linköping, Sweden.

| Barriers / Functions | Physical 1 | Physical 2 | Physical 3 | Physical 4 | Functional 1 | Functional 2 | Functional 3 | Functional 4 | Functional 5 | Symbolic 1 | Symbolic 2 | Symbolic 3 | Symbolic 4 | Symbolic 5 | Incorporeal 1 | Incorporeal 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Signature list | | | | | | | | | | | | Pre/Pro | | | Pre | |
| Medical dispenser | | | | | Pre | | | | | Pre | | Pro | | | | |
| ApoDos* | | | | | Pre | | | | | Pre | | Pro | | | | |
| Egg-cup or alike | Pre | | | | | | | | | | | | | | | |
| Delegation of medication | | | | | | | | | | | | | Pre | | | Pre |
| Laws | | | | | | | | | | | | | | | | Pre |
| Supervision | | | | | | | | | | | | | | Pre/Pro | Pre | |
| Medicin cabinet | Pre | | | | Pre | | | | | | | | | | | |
| Place for storing medicin (cabinet) | | | | | | | | | | Pre | | | | | | |
| Remainder (note) | | | | | | | | | | Pre | | | | | | |
| Color-coded schedule for care-givers** | | | | | | | | | | Pre | Pre | Pre | | | | |
| Incident reports | | | | | | | | | | | Pro | | | | | |
| Medicin list | | | | | | | | | | | Pre | Pre | | | | |
| Cosmic/Safedoc*** | | | | | | | | | | | Pre | Pre | | | | |
| Alarm | | | | | | | | | | | | Pro/Pro | | | | |
| Routine for medicine distribution | | | | | | | | | | | Pre | | | | | |
| Patients medical diary | | | | | | | | | | | | Pre | | | | |
| Binder containing patients medical information | | | | | | | | | | | | Pre | | | | |

*medical dispenser from pharmacy, **schedule shared by all caregivers in one area, covers an entire wall, ***electronic health records.

Table 2. A classification of barrier functions and the number of barriers from the home health care system.



## Discussion

The aim of this research is to identify what kind of information, and what image the two different methods convey of a service system. We are interested in clarifying whether or not they can complement each other and whether barrier analysis can be used as a design tool that emphasizes safety issues. The two methods described in this paper are very different and we do not attempt to directly compare them or recommend one over the other.

### *Blueprint*

The blueprint, as expected from a service design tool, was more effective in increasing the understanding of the patient's point of view and the understanding of processes in the home healthcare domain. It also served to visualize the service encounters and thus made them available for design valuations and suggestions of redesign.

Each service encounter is mediated, either by situated instruments (service evidence) or socially (people, rules, and roles) (Sangiorgi, 2009). The blueprint primarily shows the socially mediated actions, and the instruments chosen as part of the blueprint scenario. The instruments and interactions included are the ones most commonly used, or considered to be of greater importance. Since only one of many possible scenarios is considered, a lot of possible outcomes and incidents are not covered. When designers create a blueprint, a choice is made on what to include, which normally leads to a representation of the most common activities.

### *Barrier analysis*

Identifying all the barriers (in the care takers home environment) involved in the medication process was done fairly quickly since we had observations and documentation to rely on. The subsequent workshop verified that the relevant barriers had been included. The most challenging part was to categorize the identified barriers into the predefined classes. The ambiguous nature of many barriers, and overlapping barrier categories, sometimes made them hard to classify.

Many interactions within a system as complex and people-intensive as home healthcare depend largely on the social interactions (e.g. conversations) between individuals. Such interactions are informal and proved hard to categorize in the barrier framework, as well as in the blueprint. Also as a consequence of the social nature of the healthcare system, our analysis showed that most barriers are either symbolic or incorporeal. This is probably the case with most similar systems where service providers' actions are controlled by laws, authority, permissions, and so on. We could also see a large majority of the barriers dedicated to preventing accidents from happening, as opposed to very few that actually protected the system by dampening the effects of incidents. This was also an interesting finding from the barrier analysis that would otherwise have been hard to identify with the standard design tools.

Worth noting is that the barrier analysis identified mechanisms and artifacts that were not mentioned in the blueprint. Some mechanisms and artifacts were simply not used in the blueprint scenario and some were not covered by the levels of the blueprint. For instance, delegation of medicine, laws, supervision, incident reports and routines, are not exposed by the blueprint. These barriers can be seen as somewhat "hidden" in the system and therefore not visualized by the snapshot picture of the system the blueprint provides. However, these mechanisms are important for the system to function and critical for patient safety and would therefore be necessary to consider when creating service design in such an environment.

### *Combining the results*

Currently, barriers exist as context free entities in the barrier analysis. As a way of extending the analysis, the identified barriers was mapped onto the existing levels in the blueprint format, see Figure 2. When the list of barriers was placed into the layers of the blueprint, some interesting things happened. For instance, it was obvious that the barriers could be placed on different levels depending on who were using the barrier at the moment, who could perceive it, where it was currently placed, and so on.

Placing the barriers in the blueprint format provided a context for the barriers, by adding information about interdependencies and relations. Most barriers pertaining to physical evidence in the blueprint framework also have associated available actions. Besides being a physical evidence, an alarm can potentially be used both by the patient (customer action), onstage, or by the visiting care provider, either onstage or backstage (i.e. without the patient noticing). Some barriers also have different manifestations, for instance a manifestation in the real, physical world and a copy in the digital world. Many lists and notes for instance, are kept both in the binder at the patients home and in the medical health records. In Figure 2, the barriers were included on the blueprint layers, with some appearing at multiple layers. This is partly because the function of the barrier depends on where the barrier is, and what action is being performed, and partly because the same barrier can have an artifact, a process, or event associated, thus appearing at multiple layers in the blueprint. This makes the placement of the barriers on the blueprint somewhat difficult. It might have been possible to place the barriers in a slightly different way than in Figure 2.

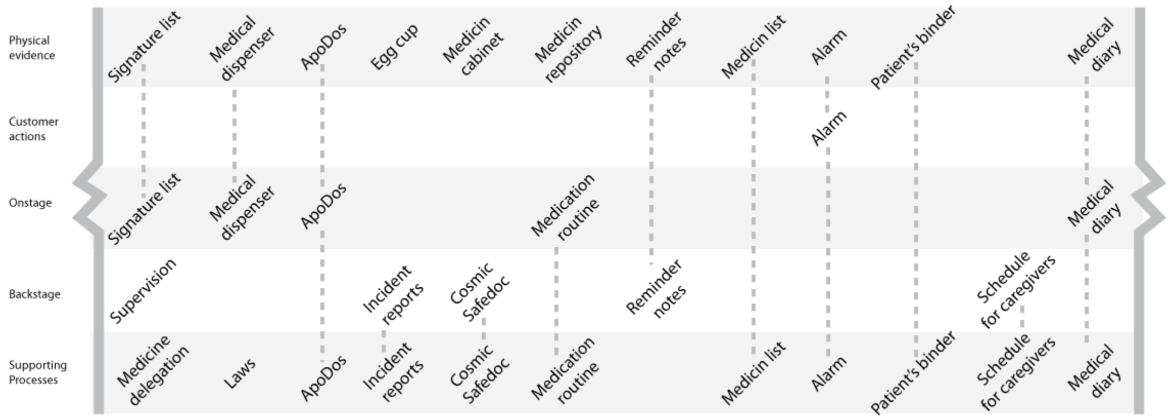



Fig 2. The list of identified barriers translated into blueprint objects.

## Conclusion

One goal of the research was to evaluate the potential of barrier analysis as a complementary design tool. The barrier analysis provided a more complete view of the objects and possible events in the system and was not dependent on a specific scenario that arbitrarily included events. The blueprint did mention most of the identified physical and functional barriers, whereas only a few of the symbolic and incorporeal barriers were included. The complete list of barriers offers ways to think about 1) where new barriers could fit in 2) what types of barriers could fit in and 3) implications of taking away existing barriers. The barriers themselves also serve as opportunities for redesign and triggers creativeness.

To be an effective design tool though, barrier analysis needs to be better described (i.e. defined) and customized to meet the requirements of design – quick, easy, and practical. The current form does however create a good floor for reflection and discussions, and the process of categorizing barriers provided insights about the domain. We have seen that actively adopting a safety perspective is important for the design of safety critical systems. The barrier analysis used in conjunction with a more traditional design method provided a richer picture that pointed out safety issues. The safety perspective also underscored that the nature of humans in such systems must be understood and that incidents should be seen as natural occurrences in any safety critical system.

It is also important to note that the barrier analysis per se does not insure that safety issues are regarded. Equally as important was the perspective itself, and using approaches and knowledge from CSE greatly affected the study. For instance, an activity associated with the CSE approach is looking at available documentation from accidents and incidents. The choice to look at the reported adverse events was a direct consequence of adopting this perspective, and lead to our focus on medication. This focus later prompted a more thorough description of our persona's medical condition, which in turn had implications for what was included in the blueprint.

### *Future research*

In an attempt to see how the two methods might work together, a simple mapping of the barriers onto the blueprint framework provided added contextual information, but to make sure that barriers are considered in design for complex systems, a complete merge of the methods could prove fruitful. Any such approach must however consider the different manifestations, uses and temporal aspects of barriers that must somehow be accounted for by the merging method. The blueprint could also be adjusted to account for episodes in the system where barriers are in effect, thus eliminating some of the problems with temporal scope that was encountered.

Furthermore we believe that service blueprinting would be useful as a complement to existing CSE methods. Service blueprinting provides a basis for better understanding complex systems from a user perspective and facilitate the process of finding better design solutions. The merits of such an approach need to be further explored.

## Acknowledgements

We would primarily like to thank Fabian Segelström for much support and input. Sture Hägglund, Leili Lind and Pontus Johnsson also contributed greatly. The research was made possible by grants from VINNOVA, the projects SERV (2007-03444) and ICE (2007-02892). We would also like to thank the healthcare organizations of Linköping and the great people within them – we admire your work!

## References

Bitner, M. J., Ostrom, A. L., & Morgan, F. N. (2008). Service Blueprinting: A practical Technique for Service Innovation. California Management Review , 50 (3), 66-94.

Cooper, A. (1999). The Inmates are Running the Asylum: Why High-Tech Products Drive Us Crazy and How to Restore the Sanity. Indianapolis, Indiana: Macmillan Computer Publishing.

Guldenmund, F., Hale, A., Goossens, L., Jeroen, B., & Nijs, D. J. (2006). The development of an audit technique to assess the quality of safety barrier management. Journal of Hazardous Materials , 130 (3), 234-241.

Harms-Ringdahl, L. (2003). Investigation of barriers and safety functions related to accidents. European Safety and Reliability Conference. Maastricht, The Netherlands.

Hollnagel, E. (1999). Accidents and barriers. Proceedings of CSAPC '99. Valenciennes: Presse Universitaires de Valenciennes.

Hollnagel, E. (2004). Barriers and Accident Prevention. Burlington, USA: Ashgate publishing.

Hollnagel, E., & Woods, D. D. (2005). Joint Cognitive Systems: Foundations Of Cognitive Systems Engineering. Boca Raton, FL: CRC Press/Taylor & Francis.

Hult, L., Irestig, M., & Lundberg, J. (2006). Design Perspectives. Human-Computer Interaction , 21, 5-48.

Hägglund, S., & Lind, L. (2006). Informationsbehov i hemsjukvården. [Information needs in home healthcare] Linköping: Santa Anna IT Research Institute.

Orre, C. J. (2009). Using Technologies with Care - Notes on Technology Assimilation Processes in Home Care. Umeå: Department of informatics, Umeå University.

Perrow, C. (1984). Normal Accidents - Living with High-Risk Technologies. Princeton University Press.

Polaine, A. (2009). Blueprint+ : Developing a Tool for Service Design. Service Design Network Conference 2009. Madeira, Portugal.

Pruitt, J., & Adlin, T. (2006). The Persona Lifecycle: Keeping People in Mind Through Product Design. San Fransisco, CA: Elsevier.

Reason, J. (2000). Human error: models and management. BMJ: British Medical Journal , 768-770.

Sangiorgi, D. (2009). Building Up a Framework for Service Design Research. 8th European Academy Of Design Conference, (pp. 415-420). Aberdeen, Scotland.

Segelström, F., & Holmlid, S. (2009). Visualization as tools for research: Service designers on visualizations. *NorDes 2009 – Engaging artifacts, Nordic Design Research Conference.* Oslo, Norway.

Segelström, F. (2009). Communicating through Visualizations: Service Designers on Visualizing User Research. *DeThinking Service, ReThinking Design: The First Nordic Conference on Service Design and Service Innovation.* Oslo, Norway.

Shostack, L. (1984). Designing Services that Deliver. Harvard Business Review , 62 (1), 133-139.

Sparagen, S. L., & Chan, C. (2008). Service Blueprinting: When Customer Satisfaction Numbers are not enough. International DMI Education Conference. Design Thinking: New Challenges for Designers, Managers and Organizations. Cergy-Pointose, France.

Svenson, O. (1991). The Accident Evolution and Barrier Function (AEB) Model Applied to Incident Analysis in the Processing Industries. Risk Analysis , 11 (3).

Wallqvist, E. (2003). Distributed cognition and home healthcare: needs regarding information handling. Linköping: Department of Computer and Information Science, Linköping University.

Winge, M. (2007). Mobisams - Mobilt IT-stöd för Samverkan i Vård och Omsorg. [Mobisams – mobile information technology support for coordination of healthcare]Stockholm: Karolinska Institutet.

Wreiner, T., Mårtensson, I., Arnell, O., Gonzalez, N., Holmlid, S., & Segelström, F. (2009). Exploring Service Blueprints for Multiple Actors: A Case Study of Car Parking Services. DeThinking Service, ReThinking Design: The First Nordic Conference on Service Design and Service Innovation. Oslo, Norway.

## Author Biography

### Johan Blomkvist

After about ten years working with care for the elderly and people with dementia, Johan got interested in human behaviour and took a bachelor in cognitive science. From there he went on to a master in design, eager to apply his newly acquired knowledge about humans as social, communicative, and embodied beings situated in cultural and evolutionary contexts. During this time, Johan also started working with user innovation and managing projects where design students collaborated with organisations and companies. His current research, as a PhD student at Linköping University, aims to expand our knowledge about prototyping services.

### Amy Rankin

After completing a Bachelors degree of Cognitive Science she spent two years in graduate school studying human behaviour in complex environments. She participated in several research projects where systemic approaches to complex systems were used, for instance accident investigation methods at a nuclear power plant, train evacuations in Sweden and flexibility in crises management organisations. Today he is a PhD candidate at Linköping University.  Her research areas are safety culture in complex social-technical systems, resilience engineering and crises management.

**Daniel Anundi**

As a graduate student in design at Linköping University with a background in cognitive science his studies have focused on interaction design and service design. His research interests includes among other things interaction aesthetics, health care and service innovation. Currently he is employed by the Swedish Meteorological and Hydrological Institute as an interaction designer and writing his master's thesis on the subject of service recovery.

**Stefan Holmlid**

Stefan Holmlid is assistant professor in interaction and service design at Linköping University, with 15 years of experience of design research in academic as well as industrial settings. He pioneered studio teaching of interaction design and service design in Sweden, and continues to teach user-driven innovation, interaction design and service design.

Currently his research interests are the expressive powers of and the involvement of stakeholders through design methods and techniques in service development and service innovation. The idea that design objects and design materials can be both dynamic, active and that the design is co-created "in use", drive his research of relevant theoretical grounding for design. His research is founded on a critical stance towards institutionalization of user-centered design.