Tracing the Scenarios in Scenario-Based Product Design
A study to support scenario generation

Irene Anggreeni Mascha van der Voort

Laboratory of Design, Production & Management, CTW-OPM, University of Twente

PO Box 217, 7500 AE Enschede, The Netherlands

Email: {i.anggreeni, m.c.vandervoort}@utwente.nl

Abstract. Scenario-based design originates from the human-computer interaction and software engineering disciplines, and continues to be adapted for product development. Product development differs from software development in the former's more varied context of use, broader characteristics of users and more tangible solutions. The possible use of scenarios in product design is therefore broader and more challenging. Existing design methods that involve scenarios *can be* employed in many different stages of the product design process. However, there is *no proficient overview* that discusses a scenario-based product design process in its full extent. The purposes of creating scenarios and the evolution of scenarios from their original design data are often not obvious, although the results from using scenarios are clearly visible. Therefore, this paper proposes to classify possible scenario uses with their purpose, characteristics and supporting design methods. The classification makes explicit different types of scenarios and their relation to one another. Furthermore, novel scenario uses can be referred or added to the classification to develop it in parallel with the scenario-based design practice. Eventually, a scenario-based product design process could take inspiration for creating scenarios from the classification because it provides detailed characteristics of the scenarios.

Keywords: product design, scenario based design, scenario classification, scenario generation

Contents

1 Introduction ... 1
1.1 Design and Design Methods ... 2
1.2 Scenario-Based Design ... 5
1.3 Research Context ... 8
1.4 State of the Art: scenarios and narratives ... 10
1.5 Research Questions ... 14
1.6 General Approach and Expected Results ... 15
2 A Design Roadmap with Scenarios ... 15
2.1 The Design Roadmap ... 18
2.1.1 Phase 1. Exploration and Orientation ... 20
2.1.1.1 Aims ... 20
2.1.1.2 Outline ... 20
2.1.1.3 Use of Scenarios ... 22
2.1.1.4 Deliveries ... 22
2.1.2 Phase 2. Requirements ... 23
2.1.2.1 Aims ... 23
2.1.2.2 Outline ... 23
2.1.2.3 Use of Scenarios ... 27
2.1.2.4 Deliveries ... 28
2.1.3 Phase 3. Conceptual Design ... 28
2.1.3.1 Aims ... 28
2.1.3.2 Outline ... 28
2.1.3.3 Use of Scenarios ... 30
2.1.3.4 Deliveries ... 30
2.1.4 Phase 4. Detailed Design ... 31
2.1.4.1 Aims ... 31
2.1.4.2 Outline ... 31
2.1.4.3 Use of Scenarios ... 32
2.1.4.4 Deliveries ... 33
2.1.5 Phase 5. Prefabrication ... 33

2.1.5.1 Aims 33
2.1.5.2 Outline 33
2.1.5.3 Use of Scenarios 34
2.1.5.4 Deliveries 34
2.2 Discussion: Beyond the Roadmap 35
3 Conclusion and Future Work 37
4 Reference 39

1 Introduction

Current design methods are well-developed and cover various fields such as consumer products, machinery, software, architecture and arts. Design, as an activity of creation, has been around since humans developed their creativity skill to solve their problems. In the beginning, we needed simple solutions to address simple problems. Products are therefore designed mainly to perform a set of functions which hopefully solve these problems. However, with the world growing more complex, we no longer have only simple problems. Most of our problems are interrelated with one another. As consumers, we have high expectation that a product takes care of as much problems as possible. Producers are aware of this opportunity. Therefore, many products nowadays consider themselves competitive by having 'different' or 'extra' attributes from other similar products. To maintain the competitiveness of a product in a selective market, product designers need to address other criteria as well. Besides making sure a good functioning of a product, users have a varying degree of concerns on the comfort of using the product (*ergonomics)*, the ease of use, learn and maintain (*usability)*, the appearance, the joyful experience of using the product and the price. At the other end of the product design, producers might prefer specific material, manufacturing method, and other criteria for the production (e.g. time frame and expense). To summarize, a design concept must be feasible and affordable. Therefore, the designer has to develop a design solution that meets all ends: users, producers and other stakeholders. There needs to be a method for designers to deliver a working design solution.

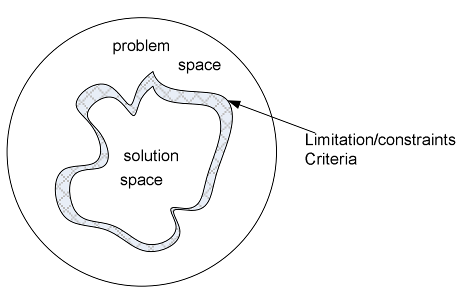


Figure 1 In a design problem space, there exist some solutions in a solution space that are restrained by design limitations and criteria.

1.1 Design and Design Methods

Cross (1994) suggests that designers understand the relationship between characteristics and attributes to be able to define a marketable product. Most producers indeed recognize that knowing what customers want is the key to product success. The "voice of the customers" reveals the desired *product attributes*. Extracting the attributes of a future product is challenging, because customers talk in (often vague) wishes and preferences. *Asking the customers* in depth is easy to perform, but the follow-up work to figuring out precisely what they want is immense. By *observing the customers* going about their activities, the designer could deduct the reasons behind their behaviours and comprehend their actions. However, observation could cause discomfort to customers that they do not act the way they usually do. The designer should be aware of the risk that critical situations can be unexplored either using interview or observation. This risk demands flexibility from the designer to find out and address these critical situations. In the case where existing competitor products are available, it is also worthwhile to conduct a market research. Customers could give their opinions about product attributes more easily when comparing with other existing products. For example, from a customer's comment on a driving wheel of an existing car product ("*This wheel is far too heavy for me, and I cannot control my car well on road turns")*, the designer gains insight into the desired product attributes. Afterwards, the designer maps out the relationships between these *product attributes* and the *physical properties* and *engineering characteristics* the product must have.

The designer must identify the physical properties and engineering characteristics which are in favour of the product attributes. A systematic way to show the relationships is by creating a matrix to show how influential the engineering characteristics are towards specific product attributes (Cross 1994). An engineering characteristic could have a positive influence on product attribute "A" as well as a negative influence on product attribute "B". In addressing the contradicting possibilities, selecting physical properties and engineering characteristics which least compromise the desired product attributes is the goal.

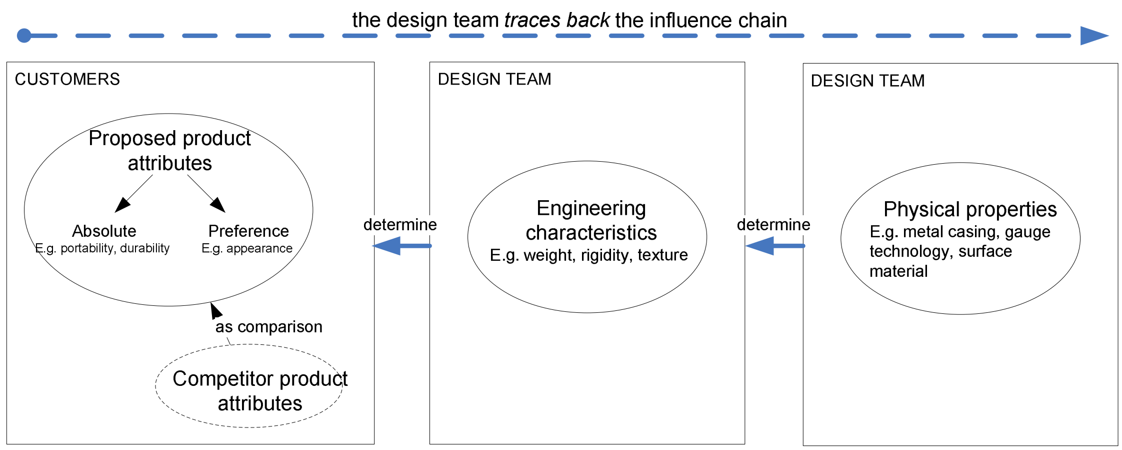


Figure 2 Designers seek to fulfil the desired product attributes by recognizing the physical properties and the engineering characteristics that deliver the attributes.

Translating the "voice of the customers" shares a similar idea as in Kansei engineering (Nagamachi 2002). *Kansei* translates to "a kind of feeling and image in one's mind" in Japanese. For instance, a customer who wants to buy a TV set would have a feeling such as "it has to look graceful and intelligent, but not so expensive…". With a history of over 30 years, Kansei engineering (KE) has been adopted by many Japanese organizations which market successful products. The method works by breaking down the zero-level concept of the product (i.e. *kansei*/ feeling) into subconcepts continuously to reach the suitable physical feature fit to these subconcepts. Further ergonomics experiments settle more detailed specification for the product. The accumulative experience of Kansei engineering practice made it possible to develop an expert system and database, which actualized a computer-assisted system of Kansei engineering. No longer only translation from *kansei* to design elements (forward KE) is possible, but also hybrid KE which holds a backward flow. In hybrid KE the designer could provide a new idea in the form of a sketch to the system. The KE system then recognizes the idea and translates it into *kansei* words. (Nagamachi 2002)

Kansei engineering focuses on building a design database to generalize the knowledge and implement it as a decision support system. On the opposite, some other methods favour a customized approach. These methods promote an active involvement of users in the design process to understand their feelings and expectations such as participatory design (Kyng 1994), contextual design (Beyer and Holtzblatt 1998) and role-playing with mock-ups (Svanaes and Seland 2004). A growing trend is integrating scenarios in the design process to support the communication between users and the designer (Moggridge 1993; Kyng 1995; Iacucci et al. 2000; Suri and Marsh 2000; Tideman et al. 2005; Brouwer and Voort 2006). All the methods mentioned above deal with translating "customers' voice"; a common denominator among them is the effort to involve the users.

Involving users is seen as a way to be proactive –instead of reactive– towards users' needs and the context of the design process. Based on this reason, many design methods are developed to help answer specific design questions. For example, several different methods as briefly discussed in the paragraph above could answer the identifying of user requirements. Each one of them applies to specific cases, but still could be useful to other design cases. The designer chooses a list of actions or methods deliberately to transform an initial idea into a final design. In other words, the designer develops his or her own 'design strategy' (Jones 1981).

Jones (1981) recognizes that designing involves three essential stages of *analysis*, *synthesis* and *evaluation*. It should be possible to cycle as many times as needed through this sequence, with each cycle being more detail than the one before it ((Asimow 1962; Watts 1966).In:(Jones 1981)). In simple words being *"breaking the problem into pieces"*, *"putting the pieces in a new way"*, and *"examining the outcomes of the new arrangement into practice"*, the analysis-synthesis-evaluation cycle is representative in any case and any domain.

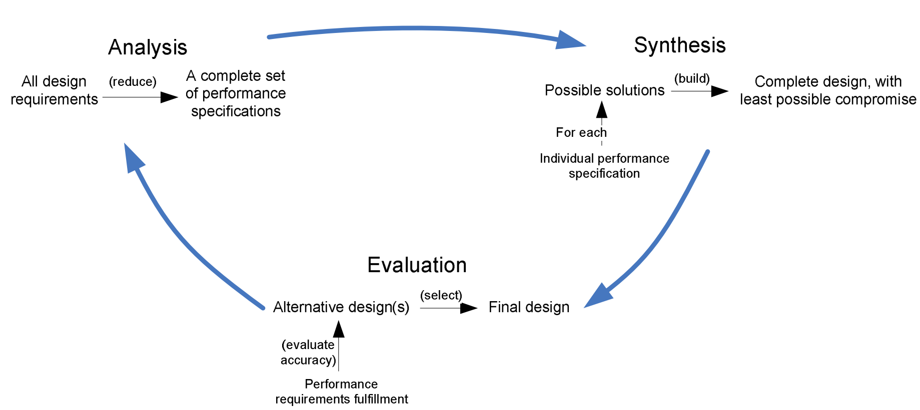


Figure 3 A summary of the analysis-synthesis-evaluation cycle (Cross 1994).

Based on this philosophy, Jones (1981) adopted some methods from the design discipline as well other disciplines and wrote guidelines on how to apply them. An 'input-output chart' is accompanying the guidelines. The chart helps select suitable design methods based on the existing data (input) and the expected result (output). This compilation of design methods have two principal common features: *formalization* and *externalization* (Cross 1994). On the one hand, *formalization* deals with widening the approach in problem and solution space, and usually also creates a basis for further research. Within a huge and complex problem space, there is a risk that some important elements are overlooked. Formalization is the remedy to this. On the other hand, *externalization* helps designers to express his design thinking into charts or diagrams and the like, to release his memory from these thoughts, and therefore give more space for creativity. Externalization also deals with communicating design ideas with others involved in the design process. Both characteristics inherent in the design methods are complementary. During the time when Jones wrote the book "Design Methods", some areas such as military, policy and decision making and strategic management have started using scenarios. However, scenarios were not yet used in the product design domain. Scenario-based approach has nowadays gained popularity in software engineering, human-computer interaction, requirements engineering and recently product design. In scenario-based design, scenarios are the main tool to formalize and externalize the design thinking.

1.2 Scenario-Based Design

The focus of our research is to study the applicability of scenario-based approach in consumer product design. As the domain of product design has only recently met scenarios, our research group is prompted to elaborate our own definitions of scenario and scenario-based design.

> *Scenarios are explicit descriptions of <u>hypothetical events</u> concerning a product during a certain phase of its life cycle. Hypothetical events could be intentional by the actor(s) in the scenario (for example, the use of a product) or unintentional (for example, the side effects of the interaction between an actor and a product).*

> *Scenario based design is a common denominator for techniques that apply scenarios to bring products, environments and their interactions into harmony.*

The definition implies that scenarios can describe current situations as well as possible imaginative futures, which is in accordance with the definitions proposed by other researchers (Nardi 1992; Carroll 1995; Carroll 2000). Suri and Marsh (2000) recognize that scenario building improves the traditional human-factors methods in consumer product design. Scenario building gives a possibility to explore and communicate the qualitative aspects of user experience early in the design process. The scenarios serve as something concrete to base discussion, argument and resolution of issues. The characteristics of being engaging, digestible and compelling make scenarios 'accessible' to anyone, and thus support interdisciplinary design teams. One important benefit, which is often not addressed by other design methods, is that scenario building explores the future possibilities of how the product will integrate into different physical and social context. (Suri and Marsh 2000)

From the information technology domain, Carroll (2000) promotes scenario-based design to answer five technical challenges by exploiting the quality characteristics of scenarios. Scenarios are *reflective*, *at once concrete and flexible*, and *multi-faceted.* They help developers coordinate their design action and reflection, without the action obstructing the reflection and *vice-versa*. The action of proposing solutions can be performed through constructing scenarios. Consequently, developers have immediate and concrete description of the solutions' uses to reflect and base design modifications on. Dealing with an ambiguous and dynamic design situation, scenarios are concrete in the sense that they can represent an interpretation of the open-ended design situation and at the same time offer a specific solution. However, they are also easily revised or elaborated when new details of the situation are encountered. Scenarios afford multiple views of interactions and level of details which acts like a magnifying glass in particular design situations. For example, a solution can be described in terms of behaviours ("Alice increase the TV volume using the remote") or specific actions ("Alice increase the TV volume by turning the knob clockwise"). At a higher managerial level, scenarios can be *abstracted and categorized* to help designers organize the knowledge they earn from their experience. Design inquiries are most of the time tailored to each particular case and therefore, unique. Abstraction and categorization of scenarios can support the development of knowledge inventories and the reuse of the design knowledge. Scenarios are the most practical and accessible *communication tool* among stakeholders because they use natural language. The figure below represents a summary of Carroll's view on scenario-based design.

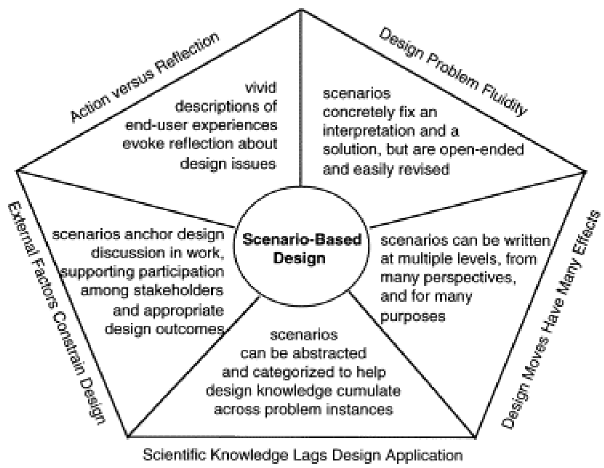


Figure 4 Challenges and approaches in scenario-based design (Carroll 2000).

Until now, many practitioners and researchers feel the lack of agreement and clear guidance in scenario-based design. Diaper (2002) points out that in realistic setting (i.e. commercial) Carroll's making use scenario guideline is too vague. Carroll (2000) argues that the heuristic nature of his scenario-based approach should be explorative, as an alternative to "top-down" design methods. The high abstract level are supposed to make designers put less commitment in design details, though in reality there is always a degree of details revealed in the scenarios. Unfortunately, the players in industry have little tolerance with anything which is uncertain whether to work successfully or not. With realistic pressure on time and financing, designers need a clear guidance to develop their own design strategy, yet enough space to improvise and follow their intuitions.

Nowadays, scenario-based approach is expanding into more area of disciplines. The experience of using scenarios from one discipline could resource methods from other disciplines. For instance, Jarke, Bui and Carroll (1998) propose an interdisciplinary framework in the requirements engineering process after reviewing scenario management from other disciplines such as strategic management, human–computer interaction, and software and systems engineering. *Scenario-based product design* indeed learns from scenario-based approaches in other disciplines and continues shaping new methods aimed for design practice (Suri and Marsh 2000; Tideman et al. 2005; Brouwer and Voort 2006).

1.3 Research Context

Practitioners of scenario-based design need to understand how to create scenarios to be able to apply it. This research will address scenario generation, an important area in the development of scenario-based product design methods. Scenario generation is the art of creating scenarios within scenario-based design. Scenario-based method requires that many scenarios be created, as the design process develops around the scenarios. What contributes to the design process is not only the result (i.e. scenarios), but also the process of creating scenarios. Most importantly, the activities to externalize and formalize the design thinking must achieve the expected results and be in balance with each other. In support of scenario-based product design, several points of attention in scenario generation have been identified.

1. The design team must have the *relevant data as input* to scenario generation. Through researching and analysing the design problem, scenario generation is a way to synthesize, externalize and formalize the design data.
2. A scenario is generated for *one or more purposes*. The purposes of creating scenarios are often not visible, until some results come out. Knowing the purposes in advance enables each design team member to cross-check the course of scenario development. In addition, the success rate of the scenario could be determined by looking at whether it fulfils its purposes or not.
3. Scenarios, just like stories, have characteristic *elements* ((Propp 1958).In:(Carroll 2000)). A combination of specific elements is always required to make the narrative in a scenario comprehensive. Some elements could be obvious such as *setting*, *agents* or *actors, goals* or *objectives*, a plot which includes sequences of *actions* and *events*. On the other hand, other elements could be more subtle, such as *unpredictable changes in the setting*, *errors, exceptions* and *actors' behaviours*

or preferences. The amount of information and the level of granularity of each element in a narrative vary with the broad use of scenarios and techniques (Karat 1995).

4. Besides the elements, the *narrative structure* and 'unfolding' help to create coherent scenarios. In creative writings, narratives could take any format which the author prefers. This is not the case in scenario authoring, because the audience are expected to grasp the explicit and implicit content of scenarios immediately. A good structure improves the quality of scenario within design context.
5. Most authors argue that scenarios are stories told from the *viewpoint* of the end users with the intention to support a user-centred design. To challenge this opinion, imagine designing a car, where the stakeholders can range from the drivers, passengers, car repairmen, traffic policemen, pedestrians and other traffic users. Each one of them has a stake in the design of the new car. For example, while a car should be spacious and comfortable for the passengers, there should be accessible space for the car repairman in case it needs service/ fixing. Scenarios told from the viewpoint of stakeholders other than the end users could reveal different aspects; all should be taken into account. In addition, scenarios from the viewpoint of the product could be exploited, for example to explain to non-designers how the product works.
6. To which extent must scenarios conform to *reality*? Creating a caricature story, such as "The Guilt Pile" (Erickson 1995), could capture a dramatic extract of the user research/ interviews. Through this story, people immediately recognize themselves (their feelings and motivations) although the story is not based on a real event. In this kind of setting, there is a freedom to reveal what is otherwise considered sensitive or embarrassing to stakeholders. As an addition to the actual scenarios, caricature stories could open new perspectives to the design task.
7. The selection of *media* for representing scenarios depends on the purposes of using scenarios. For instance, a designer would choose textual narrative, as reasoned by Carroll (2000), to make less commitment on the detailed design when the purpose is to discuss the behaviour of the user and the system. For the interaction between a user and a product however, enactment of use scenarios

accompanied by mock-ups or prototypes could be more effective than text. In practice, scenarios are more valuable with the coexistence of prototypes (Weidenhaupt et al. 1998).

Some of the points mentioned above partly have been addressed by other researchers. They are discussed in the next section, *the State of the Art: scenarios in a nutshell*. The art of generating scenarios is heuristic, assuming that writing is a natural ability that everyone has. Nevertheless, many designers especially in the beginning of practicing scenario-based methods would find more confidence in their approach and more knowledge to evaluate scenarios when a guideline for scenario generation is available. This research however will address *textual narrative scenario generation*, therefore only points number 2 to 6 above are relevant for further discussion. Point number 1 can be tackled by the existing comprehensive methods on gathering design data (Kyng 1994; Carroll 1995; Beyer and Holtzblatt 1998; Alexander and Maiden 2004). The focus on textual narrative scenario recognizes that in every scenario lies a narrative. The diverse media of representation is only a way to visualize and communicate the scenarios, yet the basic form of scenarios, similar to stories, is always the narratives. Common examples of narrative are the stories in newspapers, novels, films, or folk tales. Their main purpose is to present a message to an audience. They are not necessarily concrete and complete, and could be biased by the author's opinion. On the other hand, scenarios focus on telling situations familiar to an audience. They are written as concrete and complete as necessary, especially in regard to the relevant aspects that the author wants to highlight. Since the audience is aware of the design tasks, the scenarios engage them into thinking and acting towards resolving the design problem.

1.4 State of the Art: scenarios and narratives

Several authors have their own spread opinions about the *purpose of using scenarios*. Scenarios are open-ended and can be used for many purposes, some of which even have not arrived to our notice. Thus, the results from using scenarios could be unexpected at times. The focus is then making sense *the use of scenarios to answer specific design questions*. Nielsen (1990) categorizes scenarios by their purposes within heuristic evaluation of user interface design. They are to *communicate* user interface rationales to an audience (i.e. the users or colleagues), to *structure thinking*, and to *test* user interface or existing HCI theories. However, this taxonomy tells little about the content differences between the types of scenarios. A scenario to communicate user interface rationales, could have structured the designer's thoughts during its making. Later when receiving feedbacks during user testing, it becomes a tool to test the user interface. Campbell (1992) adapts another approach and argues for different terms to refer to scenarios based on their purposes: to *illustrate* the system, to *evaluate* system's functionality, to *design* attributes and features and to *test theory*. This proposal could not stand as a long-term solution, because the use of scenarios keeps growing. Rather than labelling scenarios by their purpose, more effort to understand the nature of scenarios in general is needed, as argued by Wright (1992). This is what the research is aiming for. Dividing scenarios by the purpose is not practically helpful in the scenario generation. This research tries to make concrete scenarios' purposes by indicating the inputs and the outputs they deliver.

With regard to the *elements of scenario*, Carroll (2000) adapts Propp's studies of narrative structure in Russian folklores (Propp 1958) and identifies that the elements of scenarios are similar to those of narratives. However, Carroll (2000) does not describe how to create scenarios and leaves this open end to the intuition of designers. Also referring to Propp's narrative structure, Potts (1995) proposes a scenario schema similar to story schemata to help designers develop a limited set of salient scenarios. Hobbs and Potts (2000) later on elaborates the research on scenario representation based on the morphology of narratives and the activities of storytelling. Their research results in the Scenario Markup Language (SCML), a mark-up implementation to represent scenarios. Being a general-purpose model, SCML can support a wide range of discussion and comprehension activities while being independent of its application area. Leite, Hadad, Doorn and Kaplan (2000) survey scenario development from organizational context and propose a conceptual model to describe scenarios. The approach aims at improving scenario management, in particular scenario organization, and is based on real experience with the use of scenarios in several case studies. The works mentioned above are conducted within some different disciplines, none of which is intended to be utilized in consumer product design. Therefore, before using the existing works, this research needs an understanding of their approach and to which extent they could be applicable in product design.

Another open end is *how much detail* and *at which level of granularity* a scenario should be. Taken for example is the description of actors in scenarios. While Carroll (2000) mentions the actors only in passing in his scenario examples, Cooper (1999) suggests that the actors (in his term, '*persona*') should be described in detail, most importantly in terms of their goals. Nielsen (2002) argues that the users in scenarios should be described 'deeply' and 'wholly' to make well-rounded and believable characters. Besides the goals and tasks, the description of a user should also include his or her *surroundings* and the *character traits* that characterize him or her. Several case studies on *persona* have revealed to which extent it works in practice, and therefore suggest ideas to make the technique more applicable in diverse organizations (Blomquist and Arvola 2002; Pruitt and Grudin 2003; Ronkko et al. 2004). The objective is to discover the limit of 'just enough' for the information to stimulate the creative design thinking. Too detailed or fine-grained information in scenarios could lead the design team to miss the big picture.

Originating from the requirements engineering, a part of the CREWS project (Cooperative Requirements Engineering With Scenarios) addresses the interpretation of textual scenarios (Achour and Rolland 1997). While doing so, the research proposes a set of guidelines for 'quality' scenario authoring. The assumption is that scenarios written in conformance with these guidelines are unambiguous and therefore can be semi-automatically analyzed. (Achour 1998; Achour 1998; Rolland and Achour 1998) This guideline could be significant towards the research on scenario generation. The guideline covers a low-level attention on the construction of sentences in scenarios. Although this research has a different aim than semi-automatic scenario analysis, scenario generation could apply some rules from the guideline that help achieve readability.

As mentioned earlier, this research is focusing on scenario generation in the textual narrative medium. The scope gives flexibility, as well as complexity, because narrative can be approached from different disciplines. Therefore, an adopted strategy is to skim the existing works in narrative generation and learn only parts of them which are applicable when the narratives are meant to serve purposes in design activities. Being the closest in term of location and collaboration, a research in digital storytelling is currently taking place in Human Media Interaction group in University of Twente (Swartjes and Theune 2006). The main interest in digital storytelling is to generate narratives using a character-centric approach. Swartjes & Theune (2006) have proposed a model consisting of the story elements and the causal relationships between them. This model can capture all that happens in the story world. The causal relationships could develop from a character-based approach, thus showing that the characters are believable and not only serving the plot. Although the application area itself is quite distant from scenario-based design, the findings encourage the possibility to implement scenario generation with a focus on the characters (*personas*). The drives of scenarios are usually the characters' actions or some external events. The elements containing the characters' traits could justify the actions, leading to the designers gaining empathy towards the people they are designing for.

A recent research by Lim and Sato (2006) addresses narrative scenario generation within the product design domain. As products have multiple aspects of use situations, a scenario construction method needs a holistic view across the multiple aspects to create a coherent and accurate structure. These characteristics are necessary for evaluating the structure later on. Design Information Framework (DIF) is a mechanism to model the multiple aspects and to generate scenarios through the models for effective management of design information. It contains three basic steps: *organizing and structuring user research data*, *creating multiple aspect models* and integrating them into integrated models as necessary, and eventually *generating scenarios* by translating the aspect models into a narrative format. Although DIF has originated from product design, a further investigation is required to see its applicability in *consumer product* design. There are differences between the design for particular users in one specific organization and the design of consumer products for inexperienced users. The DIF relies heavily on user research data on specific work environment because the product is targeted to the particular environment. While in consumer product design, combining several use practices is essential to look for structure and base solutions.

1.5 Research Questions

Several works on scenario (and story) generation have been recognized in this research and will contribute towards our research in scenario-based product design. This research itself has its niche in the generation of scenarios to support the development of innovative consumer products. The generated scenarios will focus on the interaction between users and the future product. As consumer products often have variable use situations, the scenarios aim to give insight into the use situations early in the design process.

Designing always results in something for the (near) future. The terms 'innovative' and 'future' in this report, however, refer to looking at a product with a *new use* (a product without counterpart in the present), and not redesigning an existing product. Designing for this purpose thus includes planning of a more complex system because the products being designed could interfere with one another and with the existing systems. The development of design process for the future must also be planned on the basis of what will be possible in the future. People's needs always change as the result of design activities, because to design is to alter the man-made world, which in turn affects the course of designing. (Jones 1981) Scenarios have the potentials to explore the future, and thus bring the future closer than mere imagination. However, to be able to do this, there needs to be a framework of methods to use the scenarios effectively. The generation of scenarios in particular, is a solid basis for applying scenario-based design. Therefore, extending the existing works in product design is proposed to adapt it to our research on future consumer product design.

Research questions are posed below to suggest the direction of this research.

1. What is the state of the art of scenario-based design regarding consumer product development?
2. How to classify scenarios in such a way that is constructive towards scenario generation?
3. Which scenario types and characteristics are relevant and useful in future consumer product design?
4. What is the state of art of scenario generation?
5. What criteria guide selecting the scenario types and characteristics as the aim of the scenario generation concept?

6. How to generate scenarios to fulfil the characteristics (from question 3) and meet the criteria (from question 5)?
7. How to develop and evaluate a software prototype to represent the concept of scenario generation?

1.6 General Approach and Expected Results

Different stages in a design life cycle constantly influence the purpose and content of scenarios. Therefore, the scenario generation concept is aimed to answer specific design questions within a few particular design phases. For these reasons, the design model used to describe the roadmap is made simple, easy and transparent. A software prototype of the most promising scenario generation concept will be developed and evaluated within some case studies. To adapt the applicability of the research results, several visits and inquiries in industry are planned between the literature studies. Later on, the industrial partners are also involved in the evaluation of the scenario generation concepts and the software prototypes.

The research expects to contribute in *a concept* and *a software prototype of scenario generation* in consumer product design. An intermediate result is a *scenario use classification* which is discussed in the next section.

2 A Design Roadmap with Scenarios

Scenarios, which are commonly known as the script for a film or play, emerged in a military planning strategy following World War II. It largely involved the U.S. Air Force's attempt to imagine what its opponents might do, and to prepare alternative defence strategies. Scenarios were later refined as a tool for business prognostication during the 1960s. Pierre Wack of Royal Dutch/Shell Group Planning pioneered using scenarios as a tool to "reperceive" and to make better decisions about the future. To "reperceive" means to challenge one's assumptions about the way the world works. (Schwartz 1996) Since then, scenarios are widely recognized a tool in strategic planning either in business, policy planning, decision making, and other areas which involve planning. Recently, the Swedish Defence Research Agency (FOI) has been incorporating morphological analysis with scenario generation and strategy management focusing on future studies. Morphological analysis (MA) was developed by Fritz Zwicky. It is used by FOI as a non-quantified modelling method for structuring and analysing technical, organizational and social problem complexes. (Eriksson and Ritchey 2002)

The examples above show the broadness of scenario applications, apart from what is being addressed in this research. Scenario planning focuses on the uncertainties of the future and the driving forces that influence them. It uses scenarios as a mean to capture the causal links between the driving forces in coherent logical plots. However, scenario planning leaves out the synthesis and evaluation of solutions within the plausible futures. Although the solution itself could have great influence towards the plausible futures, scenario planning stops at analysing the trends and the forces that drive them. The synthesis and evaluation of the solutions are entirely entrusted to the knowledge of the planners. Therefore, *scenario planning is considered lacking the synthesis and evaluation phases for an adaptation to consumer product design*. For this reason, scenario-based approaches in the human-computer interaction and software engineering disciplines are also studied.

Scenarios in these disciplines take a particular direction to make concrete the user activities. Carroll (2000) describes how using scenarios transforms the information system design into more mindful towards the users. Solutions often change users' activities in undesirable ways, usually because the solutions are difficult to use and to learn. Scenarios are concrete descriptions of use. By employing them, scenario-based design brings the focus of design closer to the activities that need to be supported. The concrete descriptions of the activities are exploited to examine the fittingness of solutions early and therefore drive everything else in the design process. (Carroll 2000) Building on scenario-based design, Cooper (1999) promotes *persona* technique to create fictive users. The fictive users help designers to imagine how the real users would use their product (in this case a website design) and to avoid designing for oneself. A refinement of the persona technique elaborates user research in creating the fictive users (Cooper and Reimann 2003). The persona technique complements scenario-based design method by making the designers more empathetic towards the people they are designing for.

Despite the elaborate methods, the adoption of scenario-based design in product development imposes new challenges. These challenges relate to the underlying differences between software design and product design. *Firstly*, software or a website is usually aimed at a specific target group in an organization or in a particular occupation. From the target group, an indication of the user characteristics could be obtained. For example, age range, computer literacy, visual perception, physical skill and general level of intelligence of the target users are usually visible to the designers. For that reason, there is less uncertainty regarding the users in software design than in product design. *Secondly*, the context of use of software is quite limited; most of the time the user is operating the software behind the computer –or other apparatus on which the software runs- at the workplace or a home office. On the other hand, most products are meant to be usable in different environments by different types of users who want to achieve different goals. *Thirdly*, product design affords physical interactions which involve bodily skill. Compared to software whose interactions are limited to basic hand operations, scenario use in product design requires elaborate representation to demonstrate the possible interactions. Therefore, the existing scenario-based design methods need adaptations to fit product designers' practice.

Moggridge (1993) describes an early scenario-based approach to address design of products for the elderly. The approach includes a four-step process for design: *understand* the users, *observe* them, *visualize* the possible solutions and *evaluate* them. The first two steps dedicate a great attention towards the target users, in this case the elderly. Observation is essential to understand what it is like to be other than oneself and empathize the wants, the worries and the physical and mental limitations of the target users. The visualization of solutions uses scenario building and storytelling without any initial constraint to the technical and financial implications. The evaluation step involves user evaluation with a full range of the people for whom the designed product or service is intended. Moggridge (1993) claims that storytelling or scenario building is the key point to actualize the observation and visualization steps, yet does not assume anything about the usefulness of the stories or scenarios beyond those steps. Suri and Marsh (2000) studied the development of many consumer products, in which scenario building is shown to be a powerful exploration, prototyping and communication tool. It answers the needs of human factors practitioners who are continuously improving ways to better communicate their contributions, and to involve the users as important stakeholders at all stages of the design process. Although scenario building is *a useful tool early on in the product design process*, it could benefit other phases of design process as well. These benefits beyond the early design phases are not fully address in (Moggridge 1993; Suri and Marsh 2000). These two approaches show a tendency to improvised, intuitive, and loosely defined methods. They are well in not restraining designers' creativity, but in some cases could lack guidance that the designer might overlook some aspects in the design domain.

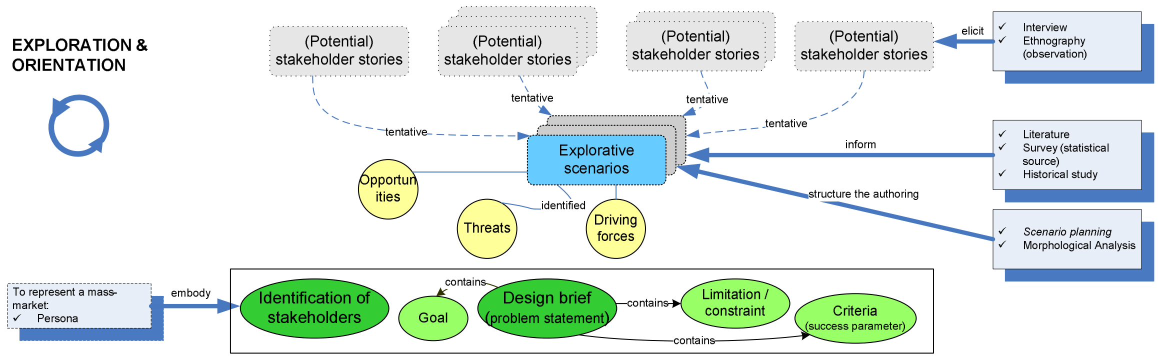
The state of affairs motivates a movement to incorporate the creative design methods with scenarios. These creative methods are not only the ones for analysis, but also the ones dealing with synthesis and evaluation of product ideas. Scenario building is indeed well integrated in existing techniques for creating solutions through role-playing (Howard et al. 2002; Svanaes and Seland 2004). The effort to incorporate scenarios in product design is also being practiced by the master students within Industrial Design Engineering programme in University of Twente. Some methods and techniques have the capacity to include scenarios as the input towards them or as the output which will be passed on to the next design step. For example, CUTA (Lafrenière 1996), a task analysis technique with the users, could retrieve information about the users' activities and their sequence of actions to perform them. Together with ethnography and user interview, CUTA could provide the necessary elements for creating daily use scenarios. Rather than listing the facts about the information, scenarios could capture more subtle details in coherent story lines. They could also be represented in many different ways that are graspable to the users. With the increasing participation of the users through participatory design, scenarios support the *communication* among designers and between designers and users (Suri and Marsh 2000). Although many methods are available, a whole design method which includes uncertainties is still missing. Therefore, the road map will propose a way for scenarios and existing design methods to support one another over an entire design process.

2.1 The Design Roadmap

The historical path and trends show that scenarios are being used in its broadest sense ranging from a script for a film or a play to a tool for business prognostication. Within the design domain, scenarios suffer from the same ambiguity because more and more uses of narratives are discovered. These narratives are referred back as scenarios. Since then some authors have tried to map out the purposes of using scenarios (Nielsen 1990; Campbell 1992; Jarke et al. 1998; Rolland et al. 1998). These classifications are applicable towards *analysing scenarios* to aid designers and researchers recollect the knowledge over scenario-based approaches. However, they do not reveal the extent to which the scenarios evolve and neither do they relate to a full-scale scenario-based design process. Although the attributes and properties of scenarios are well documented, scenario generation needs more knowledge. The essentials are from which *source* of information scenarios come from, which *elements* of information should be covered in a certain type of scenario and most importantly, *how can scenarios be created*. As a constructive "ladder" for scenario generation, the existing scenario classifications are not sufficient.

This research addresses scenario generation with a top-down approach. Instead of starting with what is already known in scenario generation, an overview of scenario uses is pursued. First, the characteristics of scenarios to be generated must be known. Yet, these characteristics might differ between scenario types and design activities in which the scenarios are used. Therefore, a formalized classification scheme is proposed at this point, to clarify the scenarios types, how they could be used and for which purposes. Design methods and techniques that relate to scenarios are suggested in this proposal. The scheme below shows that different stages in a design life cycle constantly influence the purpose and content of scenarios. The phases in the scheme are defined as a simplified synthesis of various engineering design models (Shigley and Mischke 1986; Ullman 1992; Pahl and Beitz 1996). Although these phases are not always applicable to all design projects, they are generic enough to suffice this discussion.

2.1.1 Phase 1. Exploration and Orientation



2.1.1.1 Aims

To explore, understand and synthesize information relevant to the design domain into design knowledge.

2.1.1.2 Outline

1. Discover potential stakeholders within the design domain and record their stories

Stakeholders are the people who have interest in the proposed product. The reasons for their interest could be because their lives (professional or personal or both) are going to be affected by the product, or because they are making profit from the product. These people need to be involved during the design process. Their stories are crucial ingredients for the decision making over the next steps of design activities. A group of the obvious stakeholders are the potential users of the product. However, there are other kinds of stakeholders who exist in the background yet influence the decisions during the course of designing. To refine the design brief into a clear and unambiguous one, the designer must first understand who the stakeholders are and their importance as an information source.

Through interview and observation with the potential stakeholders, fragments of information about the design task are revealed. This step serves as a preliminary learning into knowing the environment, the organization, the users' goals and roles and the work practice surrounding the design task. The relevancy of information with the design assignment is not yet the focal point at this stage. Rather, revealing the aspects that matter to the stakeholders is the main objective.

Designers need to be persistent and question user research data. For example, in (re)designing equipment at a hospital, a designer would approach the people who use the equipment in their daily routine such as doctors, nurses and technicians. A further investigation by the designer reveals that the purchase of the equipment is determined by the supplier division based on agreement with the hospital manager. To make the purchase decisions, the people from supplier division refer to ergonomic and safety standard which are set by the ministry of health. From this information, the designer knows the constraints to which his or her solution should adhere. Dealing with standard rules laid by the authority is a critical part in design; otherwise customers are reluctant to buy the product.

Looking at the example above, the designer might not be able to elicit needs from the users (for example doctors, nurses and technicians). These users might have their work activities –especially the critical ones- prescribed in procedures. It is essential for the designer to trace the decision tree back to its root: *why such procedures exist in the first place?* Answering the question opens new ways to pursue a logical solution: a new product, adjusted procedures or changes in the hospital layout. While the users and designers have many ideas to improve the work practice, there exist some boundaries (e.g. regulations) which must not be crossed.

2. The design team gathers knowledge relevant to the design field

As preparation for the next step, the design team studies and shares with each other as much as possible from literatures, interviews with experts, customer surveys, historical stories, other relevant sources of information and most importantly, from the stakeholders' stories. This process should be open-ended, and there should be no worries about little progress being produced and being overwhelmed with information. Creating repository of information will help a lot during the synthesis into knowledge through explorative scenarios.

3. The design team shares the knowledge by creating scenarios

Designers create products to change people's lives in better ways. They are challenged to imagine how the lives would be with their design up front, and whether it is worthy at all to pursue the design solution. However, to understand to the full extent how a product changes people's lives is only possible when the product becomes available. This implies that it is usually too late, when the product is already produced and the designer realizes that it affects life for worse. To make the designers aware of the situations, they must brush with the possible experiences using the proposed product. Scenarios can capture the experiences before any commitment to the design work is done.

Similar to strategic planning, there are many uncertainties in regard to design that force the design team recognize alternative and "what-if" situations. Identifying relevant trends and their driving forces reveals what opportunities and threats there are. Choosing only a few most important and most uncertain driving forces helps focus the scenarios. (Schwartz 1996; Heijden 2005) Among the possible means to achieve this are brainstorming, SWOT analysis (Heijden 2005), morphological analysis (Ritchey 2002-2006). As the result, the design team becomes more aware of the kind of future being shaped by the design solution.

2.1.1.3 Use of Scenarios

1. (Potential) stakeholders' stories

Design is about influencing people's lives. Therefore, building a good relationship with these people (i.e. the stakeholders) is the first step towards knowing them: *what matters to them*, and *which aspects of life or work they want to improve*. Asking the (potential) stakeholders to share stories of their lives is a natural choice to understand them.

2. Explorative scenarios

Stakeholders' stories and other information could be transformed into one or more coherent scenarios about the possible futures. These scenarios contain reflections towards the strategy that the designer takes on, and therefore help shape the necessary decisions to solve the ill-defined or open-ended design assignment. While creating explorative scenarios, the designer also learns about the *driving forces* that influence the design domain and the *threats* and *opportunities* that could rise from them.

2.1.1.4 Deliveries

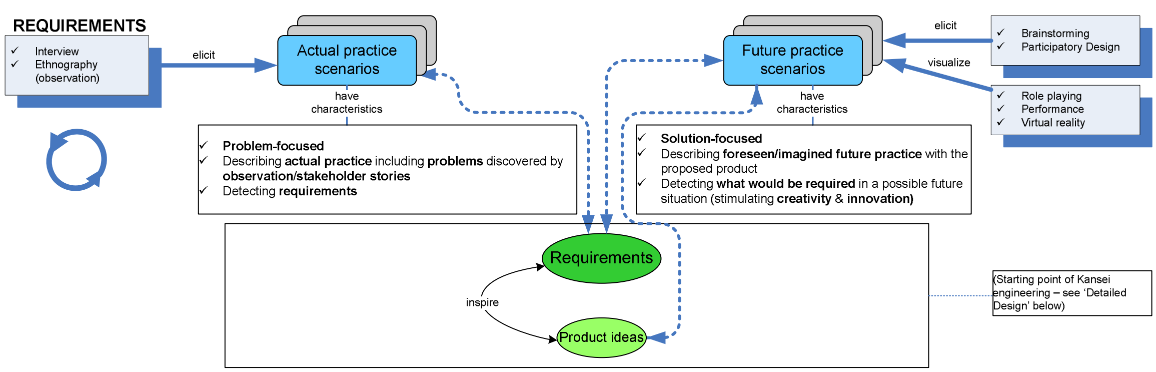
1. Identification of stakeholders

Involving stakeholders as collaborators proves to be beneficial throughout the design process. Participatory techniques such as described by Kyng (1994) could provide a continuous validation of the design progress together with the stakeholders. However, involving stakeholders directly is not always possible. For example, consumer product design is usually targeted to serve a mass market without specifically known target users. To answer this challenge, *personas* could be the remedy against designing for oneself due to difficulties to involve the stakeholders. *Personas,* based on user research, embrace the social and political aspects of the stakeholders, making the designer aware of these aspects. (Grudin and Pruitt 2002)

2. A workable design brief

The design brief is sometimes also called *problem statement*. The statement embodies a *goal*, some *constraints* within which the goal must be achieved (for example, laws and regulations), and some *criteria* by which a successful solution can be recognized. The problem statement could evolve as often as necessary during the design process, because sometimes the search towards solutions could lead to a redefinition of the problem. The evolution of the problem definition is part of the design itself. (Cross 1994)

2.1.2 Phase 2. Requirements



2.1.2.1 Aims

To discover requirements which, supposedly fulfilled, would address the actual problems. To articulate potential product ideas and requirements that arise from them.

2.1.2.2 Outline

A set of requirements is an elaboration of the problem and solution definition. In practice, problems and solutions evolve together throughout the design process. Every proposed solution affects the problems, whereas the problem redefinition reveals possible solutions that lie outside the boundaries of what was assumed to be possible. (Cross 1994) As a strategy to cope with this intertwined problem-and-solution definition, designers could employ two complementary approaches in acquiring requirements. One approach is by *looking at the actual (problematic) situations and discovering ways to solve the problems.* The other approach *starts from ideas for solutions* that –in line with the designer's intuition- might work. Further on, the designer imagines more requirements that might arise in case the ideas were applied. Scenarios play roles in both approaches, although their sources of inspiration and characteristics differ between cases. Both approaches propel each other into creating a more detailed set of requirements.

The solution-focused approach might seem ahead of its time within the requirement phase. However, designers could have emergent ideas to solve a design problem. Experimenting on the ideas' fittingness in some particular situations is a way to understand the ill-defined design problem. A future practice scenario is imagined with the solution idea to determine what more would be required if such solution were implemented. A future practice scenario could also highlight important and uncertain aspects which are identified through the scenario thinking during exploration & orientation phase. In this case, the designer is compelled to measure his solution ideas against the uncertain futures objectively.

Kruger & Cross (2006) analyzed data from protocol studies of nine experience industrial designers and identified four different cognitive strategies employed by the designers: *problem driven, solution driven, information driven,* and *knowledge driven* design strategies. Most of these designers employed either a problem driven or a solution driven design strategy, with each of these strategies being equally prevalent. Although solution driven design did not feature clearly as the dominant strategy, the 'generate (solution ideas)' activity was the most frequently occurring single activity. This confirms that thinking of solutions –even when the problem is not yet fully understood- is a natural part of design. Therefore, the road map recognizes the solution-focused approach and proposes using future practice scenarios within this approach. These scenarios are relevant because the solution-focused approach is trying to put solutions in their use situations, which are potentially happening in the future.

Problem-focused approach

1. Discover problems from various stakeholders

The stakeholders (especially users) cannot always articulate their problems and needs. They could get used to problems and eventually regard them as normal parts of their daily lives. For instance, we think that waiting for our computer to start is normal, and we are used to get around it by taking coffee while waiting. Problems could also be subtle at times. Therefore, the designer should not take for granted the stories from stakeholders; rather try to break down the stories to understand the underlying requirements. One principle is then to be pragmatic, that is asking "why" continuously to the stakeholders, until the causes of the problems are visible. One simple practice to acquire the requirements from the users is by asking them to tell stories about their lives (Robertson 2004). The aim is to get as complete description as possible of the use practice. When this is not sufficient, the designer could employ ethnographic studies on the environment. The *contextual design* method discusses profoundly how to conduct a contextual inquiry at work by adopting a master-apprentice relation model (Beyer and Holtzblatt 1998).

2. Wrap up the problems from stakeholders in scenarios

Stakeholders having similar roles could share overlapping and complementary stories. The designer should be apt to combine these stories into coherent scenarios with unambiguous context. Besides the normal situations, the scenarios should as well explore critical situations. The stories about these critical situations should come out during the interviews and observations of the users.

3. Identify necessary conditions which could help to tackle the problems

The scenarios generated in the previous step are not the end-result, rather as a tool to illustrate the problems. When problems are identified, the designer could get some insights what conditions are required to prevent or mitigate them. The designer might not know yet what kind of design solution he would pursue. Therefore, the requirements at this stage could be high-level and only describing basic characteristics that should be fulfilled by the solution. For instance, designing a product that is required to be *portable* could lead to either the product is so light that it is easy to carry or it is mounted with wheels to be pushed around. The designer does not need to decide right away how to achieve the characteristic of portability. Many more requirements will be revealed at this phase and they will make clear the ways to accomplish the solution.

Things to look out for in problem-focused approach:

- Creation of "solution patches" to an existing product. A product is developed with technologies on its time. These technologies can grow obsolete at some point and be replaced by a new breed of technology. For example, the disk storage technology began with the simple floppy disk and later advanced into the small USB flash drive. The technology is still advancing noticeably that it must be taken into consideration when designing new electronic equipment that needs storage. Therefore, the designer must also keep an eye on the progress of other areas which could support his design.
- Ignorance of problems that are not directly related to the main functionality of the product. For instance, a fitness machine serves its purpose well, yet it could be difficult to store or transport and maybe even too noisy when being used. Therefore, the designer should keep in mind the big picture of his solution. Additionally, the designer could learn about approaches that failed in the past and the reasons of the failures, so that he or she does not reinvent the wheel.

Solution-focused approach

1. Externalize any ideas and communicate them to stakeholders

When only words are not enough to describe the idea, the designer could explore other tools such as drawing, CAD model, demonstrator or mock-up. Ideas involving physical form usually need much visualization, yet there should scenarios accompanying these ideas. The scenarios could tell how the ideas work and in which way they satisfy the requirements.

2. Create future scenarios about how the ideas influence the design domain if they were implemented

There are two ways to combine the elements for future practice scenarios. The first option is by creating scenarios *based on current situations with the ideas implanted*. From here on, the ideas can be assessed, whether they remedy some of the requirements or not. Furthermore, the ideas could raise more additional requirements if they were to be implemented. If the ideas endure the next phases and the additional requirements are manageable, then the ideas are considerably suitable for follow-up. The second option is *by inserting few uncertainties in the scenarios and looking whether the ideas survive or not*. The uncertainties are discovered from the exploration and orientation phase. If the uncertainties affect the success of the solution greatly, the scenarios can make the design team aware of the risks and threats inherent in the solution.

3. Identify tentative requirements

Design ideas open new ways to perceive the design tasks. For example, some ideas could give several tentative directions to pursue the design solution. The design team then considers the tradeoffs of each set of these requirements. Being tentative, the design team can refine them in later phases when the direction for solutions is becoming clearer.

Things to look out for in solution-focused approach:

- Loosing rationality and dwelling into one idea without any further validation. An indicator to this is when the scenarios are always rosy because they serve as justification of the ideas. To avoid the *rosy* design process, stakeholders and experts from other disciplines are involved in the evaluation of the ideas in the later phase.
- Over criticism that some potential ideas never get into the table of discussion.

2.1.2.3 Use of Scenarios

1. Actual practice scenarios

Based on the interviews and ethnographic studies, the designer understands the expectations of the product's future users. In addition, the designer also learns the boundaries of the design solution and the environment in which the product is going to be operated. Creating scenarios strengthens the understanding and gives rationales to the requirements. The *actual practice scenarios* capture all elements relevant to the problems based on contextual observations and interviews with users.

2. Future practice scenarios

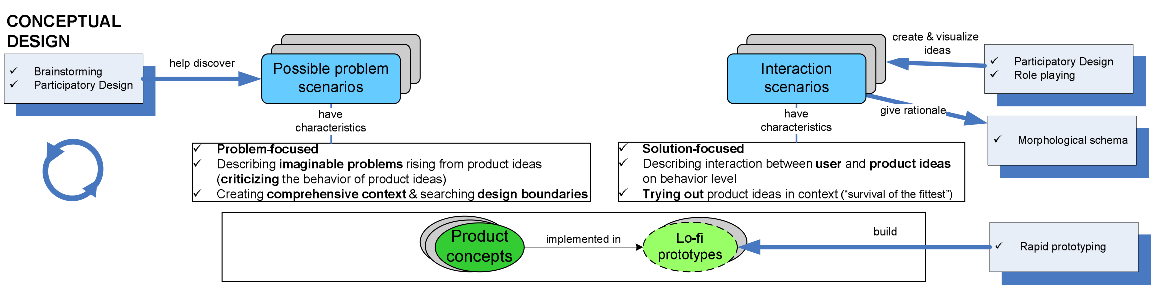
Any immediate idea can be expressed in scenarios and scanned for suitability early on. The *future practice scenarios* describe imagined futures with the existence of one or more product ideas: *"would people use the product?", "how might people perform their activities if such product were available?", "how would the product affect their lives?"*. The consequences of these ideas lead to requirements identification. The future scenarios allow imaginative exploration of ideas and solutions.

2.1.2.4 Deliveries

A set of requirements

The requirements are high-level in the beginning of the design phases. However, they are continuously refined into a set of concrete specification throughout the design process.

2.1.3 Phase 3. Conceptual Design



2.1.3.1 Aims

To generate one or more product concepts as coherences of product ideas.

2.1.3.2 Outline

The conceptual design phase is the most creative one because this is where synthesis of ideas into concepts happens. A product idea could inspire functionality or sometimes prevent the implementation of other ideas. Developing concepts from ideas requires the designer to jump intuitively from fitting a solution concept into use situations iteratively. The *interaction scenarios* are the means to express and document this activity. Besides exploring solution-use situation space and looking for alternatives creatively, the designer needs to be critical to ensure the concept development. Many *possible problem scenarios* can be created to specifically describe how the product ideas could withstand some extreme situations or even cause more unanticipated problems. A designer cannot always hold this dualism. Therefore, the design team and stakeholders together in participatory design methods could validate the concept.

1. Synthesize product ideas into concepts

From several ideas, the design team tries to make one or more combinations of ideas that are promising. The designer could use intuition or make use of a more structured method such as *morphological chart* as explained in (Cross 1994). The morphological chart method generates alternatives for concepts through combination of several functions. The chart method makes the evaluation process explicit, therefore reducing the chance that some potential concepts unnoticed. It is also easier to evaluate the concepts which are already made explicit in participatory manner by team members and stakeholders from different disciplines.

2. Explore problems which could happen if the product concepts were implemented

The design team needs reasons as to why a concept is suitable or not. Scenarios are an appropriate medium to comprise the reasons. They could provide explanations over the selection of product concepts. Looking at it the other way around, a choice of a concept over the others can be accompanied by scenarios which describe the rationale behind it. For example, scenarios could be a basis for evaluating the alternative concepts in the *morphological chart* (Cross 1994).

3. Reflect on the plausible problems from step 2 and evaluate the concepts

The syntheses of ideas which do not perform well are not pursued further. Therefore, this principle serves as a natural selection process during conceptual design phase. On the other hand, with the promising concepts, the designer has also been made aware of the risk and consequences through the problem scenarios. There is sufficient knowledge as the basis to refine the concept or alter the concept completely.

2.1.3.3 Use of Scenarios

1. Possible problem scenarios

Being the critical counterpart of the product concept development, the scenarios should imagine problems that rise from the existence of such product, far before the product really comes to existence. The design team refines the ideas to prevent or mitigate the problems.

2. Interaction scenarios

The scenarios show interactions which could happen between the future user and the proposed product. These interactions can be comfortably expressed in terms of behaviours. The scenarios therefore contain only the context of use, the user and his intentions, and how the product behaves in relation with the former two elements. The descriptions of these components intentionally avoid low-level detail and can be as shallow as shown in the figure below. The elaboration of these ideas is addressed later in the detailed design phase.

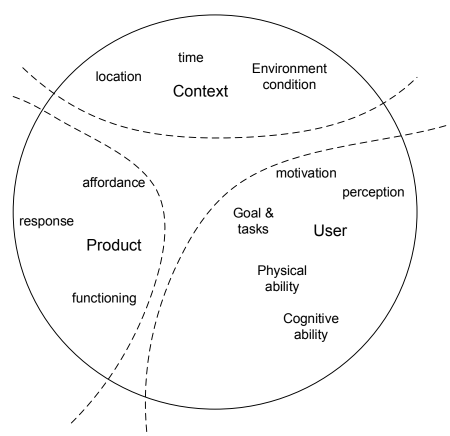


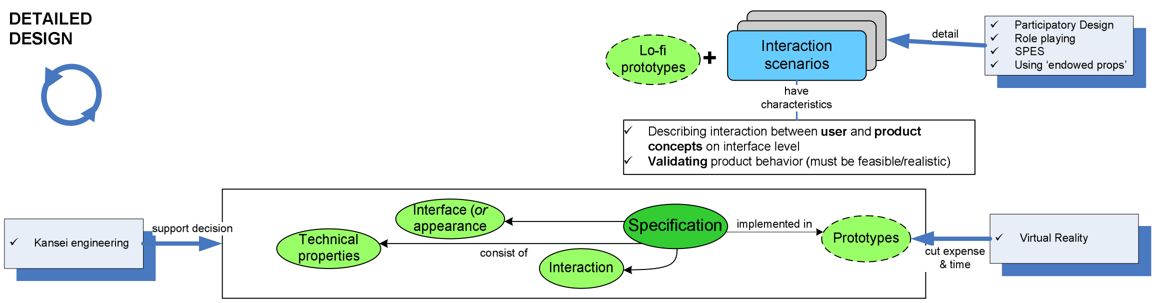
Figure 5 The coverage of interaction scenarios in conceptual design phase

2.1.3.4 Deliveries

Product concepts

A product concept, similar with the requirements, could begin with a high-level description and will be detailed iteratively. The concept description can cover, for example, a set of product behaviours, the product shape and the technology for the product. Low-fidelity prototypes could be developed to give a rough look for the concepts.

2.1.4 Phase 4. Detailed Design



2.1.4.1 Aims

To elaborate the product concept or concepts into detailed specifications.

2.1.4.2 Outline

The detailed design phase is an extension of the conceptual design phase and can be conducted as many times as needed. Within consumer product development, the detailing largely concerns the interface and interaction design of the product. Further on, the concepts also go through detailing iteratively into technical specification such as fabrication techniques, technologies and materials. The designer attempts to evaluate the product concepts and their feasibility before all the characteristics are determined. Stakeholders, especially the potential users, are often involved in participatory methods to elicit the interaction (and interface) they want for the product. If this is the case, designers must ensure that the interaction and interface are feasible. This could be done practically by reusing *interaction scenarios* from the conceptual design phase in “walk-through” sessions with users. Thus, from “walking through” the conceptual interaction scenarios, the users themselves fill up the undetermined details of the solution. Besides using scenarios, there is another approach to make the detailing more structured, namely Kansei Engineering (KE). With over 30-year experience, KE has built knowledge database for translating the customer's emotion into the product design domain and *vice versa*. A hybrid KE could hold a backward flow, namely translating back a design concept into emotions which would be perceived by the customers (Nagamachi 2002).

Having a sufficiently-detailed specification would prompt the designers to build prototypes whenever possible, to check if the concept works in reality. However, time, money or bureaucratic constraints do not always allow this. Fortunately, the development in virtual reality technologies affords another way of evaluation. Tideman et al (2005) suggest that using virtual reality technologies help users to experience specific scenarios and to define solutions themselves. From observing users' actions in the scenarios and acquiring users' feedback, the designer could cross-check between the users' real needs and what users claim to need: thus, gaining profound insight on the context of use of the product.

1. Starting with the interaction scenarios from the conceptual design phase, describe the interaction and interface details for each concept

From each concept-levelled interaction scenario, similar scenarios are developed by adding detailed interaction, description of interface and information flow. The designer explores the technologies and the implication of a product attribute towards other aspects. For example, a desired strong and firm attribute for a product leads to a choice of light aluminium as material. This choice influences the product's weight, and consequently the way the user handles the product.

2. Reflect on the feasibility of implementing the concepts

The many choices for carrying out a concept leave the designer to decide. An aspect of consideration is whether the way of implementing the concept is feasible with the progressing technologies, facilities, time and budget, and the product's value. Some of these sanity checks help the designer to choose which concept or concepts to elaborate more deeply.

2.1.4.3 Use of Scenarios

(Detailed) interaction scenarios

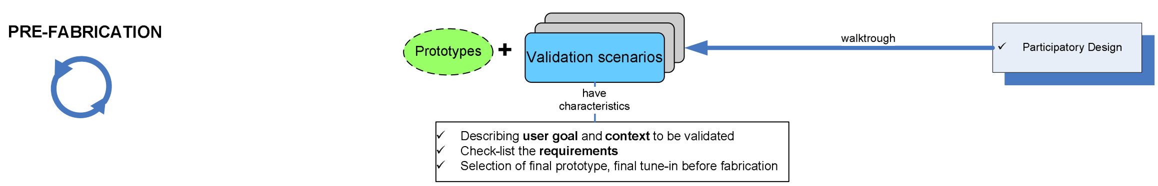
The interaction scenarios in detailed design phase are elaboration of the interaction scenarios from the previous phase. They are not only showing the behaviour of the product and the user (the "what"), but also the actions which prompt the behaviours (the "how"). The story lines from the conceptual interaction scenarios are maintained as much as possible. However, if the designer realizes that product behaviour is not feasible, there should be flexibility to revise the original conceptual interaction scenario to conform to the new scenario.

2.1.4.4 Deliveries

Specifications

A product specification should contain a combination of the three components: *technical properties* (material, dimension, and shape), *interface* (components of the product with which the user interacts), and *interaction details* (actions and responses of the product). When it is cost and time effective, a high-fidelity prototype can be produced to exhibit the real feel of the product.

2.1.5 Phase 5. Prefabrication



2.1.5.1 Aims

To detect any false specification before the fabrication.

2.1.5.2 Outline

The design phases –conceptual and detailed- aim to generate the solution, with the designers attempting to be aware of the requirements defined in phase 2. To avoid overlooking some requirements ("I really did think of that, but I forgot…") or other more subtle criteria ("Did the user say he likes it this or that way?"), the designer needs to "check-list" the requirements and put back the almost-finalized solution in some situation scenarios. Using the scenarios is a way to "walk-through" the solution in various situations to ascertain that the solution meets the criteria which the stakeholders would have preferred but not concrete enough to express as requirements. The participatory methods in this phase allow the users to imagine themselves in some situations with (the prototype of) the solution as an aid to solve problems they encounter in those situations.

1. Extract situations from existing scenarios created in the gathering requirements phase

Throughout the design process, requirements are being transformed continuously from *humanly* requirements into *technical* requirements. Due to immense information and miscommunication or just simply put, mistakes, some information might be missing somewhere in between the transformation. All products are designed to change human life for the better, therefore referring back to the humanly requirements is sensible. The requirements which are firsthand acquired from stakeholders are comprised in the actual and future practice scenarios from the requirements phase. From these scenarios, the designer selects situation scenarios which are the most occurring, challenging and critical in regard to the use of the proposed product. These selected scenarios are referred as validation scenarios.

2. Check the fulfilments of each requirement and the satisfaction level with other criteria

The validation scenarios highlight requirements and some more subtle criteria. A solution that does not fulfil the requirements will need a major modification before being fabricated. In case more than one solution still prevails in this phase, both requirements and criteria checklist would assist the selection process so that the fabrication continues with only the best solution.

2.1.5.3 Use of Scenarios

Validation scenarios

The validation scenarios do not need to be new; they take inspiration from the actual and future practice scenarios from the requirements phase. The idea is to extract the environment, the goals of the actor and the unexpected elements from the situation scenarios. Afterwards, the users try the product within these situation scenarios. The "product" can either be in the form of a real prototype or only a concept.

2.1.5.4 Deliveries

The possible deliveries of this phase are the *"go" signal to fabrication* or *some minor changes* to the design specification. However, a lack of stakeholder involvement throughout the design process could lead to detecting major problems even in this late phase such that the designer must alter the solution completely.

2.2 Discussion: Beyond the Roadmap

The scenario roadmap below provides a rough overview of how stories and scenarios could evolve in a scenario-based product design process. We continue to reflect on the advances in scenario works in research and practice. There are already far too many terms to refer scenarios, with each term highlighting a special role of scenarios. Nevertheless, we hope that the identified scenario types could provide a common "language" for discussion within this research context.

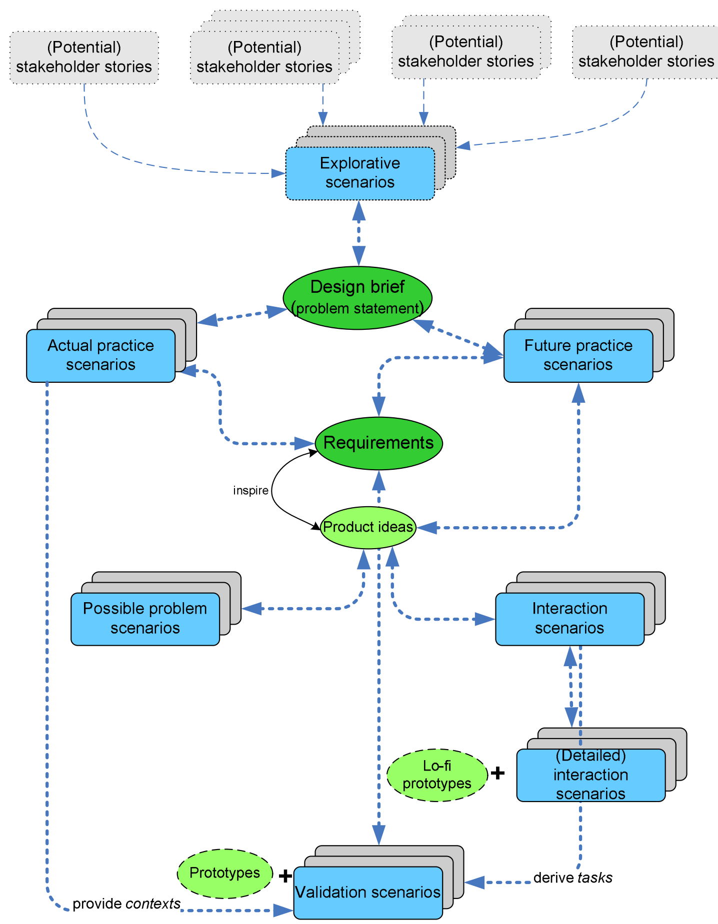


Figure 6 The overview of relationships between scenarios

Throughout a scenario-based design process, many scenarios of different content, representation and purpose are created. Each one of them could be an informal documentation of the design project. Scenarios contain rationales of the decisions made throughout the design process. Although the rationales themselves are not explicit, scenarios give subtle details that explain the context considerably. Some authors in object-oriented software design promote scenarios as use-case instances (Rumbaugh et al. 1991; Rubin and Goldberg 1992), although the term *use cases* is still preferred as a formal way to discuss all the ways a system is going to be used (Jacobson 1995). In our opinion, scenarios are always inherent within use-case models no matter which term is being used. There is a notion of action and event sequence in a use case as is in a scenario. Whenever one follows through a use case, the result is a form of narrative. However, in comparison with scenarios, use case models are lacking the context of use and unpredictable elements that influence the user interaction with the system or product. While scenarios try to cover the big picture, use cases put a narrow focus on the functionality of the proposed system. Consumer product design will need to incorporate the context of use in addition to the functionality. Other case studies demonstrate how scenarios are used as rationales of logic behind the programming requirements (Alexander and Maiden 2004). In any case, brief, descriptive and clear scenario titles are helpful to achieve traceability during the product development.

Beyond the documentation purposes, the scenario narratives are a great starting point for after-production/sales purposes such as the writing of user manuals and promotional materials. To attract customers, showing the kind of problematic situations which could be resolved by the product (the *benefits*) is far more effective than listing the *features* that the product has. Using and “recycling” scenarios throughout and after the design process assist designers to build and keep a firm connection with the *man-made world* –as expressed in (Jones 1981)- they are about to change with their design.

3 Conclusion and Future Work

Scenario-based product design has not had its full potentials explored. An essential activity that lacks support is scenario building. Current approaches in scenario generation are mostly aimed for requirements engineering (Achour 1998; Achour 1998; Maiden 1998; Maiden et al. 1998; Tawbi et al. 1998; Leite et al. 2000; Shin et al. 2005). On the other hand, scenarios can actually be used for other purposes. This motivates the research towards an automatic scenario generation for product design to start with classifying scenarios based on their purposes and characteristics. The classification informs us about methods which could be used together with scenarios, results which could be expected, and the way scenarios give significance to the particular design phase. To build the classification, this research includes the possible extension and evolution of the scenarios to gain a thorough understanding on scenario practices. An overview of scenario uses will serve as a grounding for scenario generation. After the analysis of each classified scenario, the scenario generation could be aimed at scenario types selected based on the criteria which will be identified later on in this research.

This report has answered the first two research questions resulting in: 1) the state of the art of scenario-based design, 2) an overview of scenario uses in consumer product design, and 3) a scenario classification scheme that is useful for building the scenario generation concept. The next steps for this research aim at *analyzing characteristics* of each scenario type and *understanding the state of the art of scenario generation*. The two fields of studies overlap because the review of scenarios' elements and structures lies intensively within the research on scenario construction. The expected mediate result from the steps is a network model that represents scenarios' elements and their connection with one another.

Upon gaining knowledge on the state of the art of scenario generation, we hope to identify the scenario types which are lacking of support. This information leads to a priority list on which we could base the choice of scenario types to be generated. The scenario generation concept proposed in this research will therefore focus on specific subtypes which will be defined later on. Some tentatively-identified subtypes are:

- *strategic scenarios* to identify and highlight the changes of context in the future

- *dynamic use scenarios* to address the varying use of a product
- *task-artefact cycle scenarios* to express the possibilities of new functionality leading to certain directions in product design.

4 Reference

Achour, C. B. (1998). Guiding Scenario Authoring. 8th European-Japanese Conference on Information Modelling and Knowledge Bases, Vamala, Finland.

Achour, C. B. (1998). Writing and Correcting Textual Scenarios for System Design. 9th International Workshop on Database and Expert Systems Applications (DEXA'98), IEEE Computer Society.

Achour, C. B. and C. Rolland (1997). Introducing Genericity and Modularity of Textual Scenario Interpretation in the Context of Requirements Engineering, Centre de Recherche en Informatique, Universite de Paris 1, France.

Alexander, I. F. and N. Maiden, Eds. (2004). Scenarios, Stories, Use Cases: Through the Systems Development Life-Cycle, John Wiley & Sons, Ltd.

Asimow, M. (1962). Introduction to Design. New York, Prentice-Hall.

Beyer, H. and K. Holtzblatt (1998). Contextual Design: Defining Customer-Centered Systems, Morgan Kaufmann Publishers, Inc.

Blomquist, A. and M. Arvola (2002). Personas in Action: Ethnography in an Interaction Design Team. NordiCHI, Aarhus, Denmark, ACM Press.

Brouwer, M. and M. C. v. d. Voort (2006). Design for Dynamic Use Situations. Wonderground 2006 Design Research Society International Conference, Lisbon, Portugal.

Campbell, R. L. (1992). "Will the real scenario please stand up?" SIGCHI Bulletin **24**(2): 6-8.

Carroll, J. M., Ed. (1995). Scenario-based Design: Envisioning Work and Technology in System Development, John Wiley and Sons.

Carroll, J. M. (2000). "Five reasons for scenario-based design." Interacting with Computers **13**(1): 43-60.

Carroll, J. M. (2000). Making Use: Scenario-Based Design of Human-Computer Interactions, MIT Press.

Cooper, A. (1999). The Inmates are Running the Asylum, Macmillan.

Cooper, A. and R. Reimann (2003). About Face 2.0: The Essentials of Interaction Design, Wiley Publishing, Inc.

Cross, N. (1994). Engineering design methods: strategies for product design, John Wiley & Sons.

Diaper, D. (2002). "Scenarios and task analysis." Interacting with Computers **14**(4): 379-395.

Erickson, T. (1995). Notes on Design Practice: Stories and Prototypes as Catalysts for Communication. Scenario-based design: envisioning work and technology in system development J. M. Carroll, John Wiley & Sons, Inc.

Eriksson, T. and T. Ritchey (2002). Scenario Development using Computerised Morphological Analysis, Swedish Defence Research Agency (FOI).

Grudin, J. and J. Pruitt (2002). Personas, Participatory Design and Product Development: An Infrastructure for Engagement. PDC.

Heijden, K. v. d. (2005). Scenarios: The Art of Strategic Conversation, John Wiley & Sons, Ltd.

Hobbs, R. L. and C. Potts (2000). Hyperscenarios: a framework for active narrative. 38th annual on Southeast regional conference, Clemson, South Carolina, ACM Press.

Howard, S., et al. (2002). Using 'Endowed Props' In Scenario-Based Design. NordiCHI, Arhus, Denmark.

Iacucci, G., et al. (2000). On the Move with a Magic Thing: Role Playing in Concept Design of Mobile Service and Devices. DIS, Brooklyn, New York, ACM.

Jacobson, I. (1995). The Use-Case Construct in Object-Oriented Software Engineering. Scenario-based design: envisioning work and technology in system development J. M. Carroll, John Wiley & Sons, Inc.

Jarke, M., et al. (1998). "Scenario Management: An Interdisciplinary Approach." Requirements Engineering **3**(3): 155-173.

Jones, J. C. (1981). Design Methods. Chichester, Wiley.

Karat, J. (1995). Scenario use in the design of a speech recognition system Scenario-based design: envisioning work and technology in system development J. M. Carroll, John Wiley & Sons, Inc.**:** 109-133

Kruger, C. and N. Cross (2006). "Solution driven versus problem driven design: strategies and outcomes." Design Studies **27**(5): 527-548.

Kyng, M. (1994). Scandinavian Design: Users in Product Development. SIGCHI conference on Human factors in computing systems: celebrating interdependence, Boston, Massachusetts, ACM Press.

Kyng, M. (1995). Creating contexts for design. Scenario-based design: Envisioning work and technology in system development. J. M. Carroll. New York, Wiley**:** 85-107.

Lafrenière, D. (1996). "CUTA: a simple, practical, low-cost approach to task analysis." interactions **3**(5): 35-39

Leite, J. C. S. d. P., et al. (2000). "A Scenario Construction Process." Requirements Engineering **5**(1): 38-61.

Lim, Y. and K. Sato (2006). "Describing Multiple Aspects of Use Situation: Applications of Design Information Framework to Scenario Development." Design Studies **27**(1).

Maiden, N. (1998). "CREWS-SAVRE: Scenarios for Acquiring and Validating Requirements." Automated Software Engg. **5**(4): 419-446.

Maiden, N., et al. (1998). CREWS-SAVRE: systematic scenario generation and use. Requirements Engineering, Colorado Springs, CO, USA.

Moggridge, B. (1993). "Design by story-telling." Applied Ergonomics **24**(1): 15-18.

Nagamachi, M. (2002). "Kansei engineering as a powerful consumer-oriented technology for product development." Applied Ergonomics **33**(3): 289-294.

Nardi, B. A. (1992). "The use of scenarios in design." SIGCHI Bulletin **24**(4): 13-14.

Nielsen, J. (1990). Paper versus computer implementations as mockup scenarios for heuristic evaluation. IFIP TC13 Third International Conference on Human-Computer Interaction, North-Holland Publishing Co.**:** 315 - 320.

Nielsen, L. (2002). From user to character - an investigation into user-descriptions in scenarios. DIS, London.

Pahl, G. and W. Beitz (1996). Engineering Design: A systematic approach. London, Springer Verlag Ltd.

Potts, C. (1995). Using schematic scenarios to understand user needs. Designing interactive systems: processes, practices, methods & techniques, Ann Arbor, Michigan, United States, ACM Press.

Propp, V. (1958). Morphology of the folktale. The Hague, Mouton.

Pruitt, J. and J. Grudin (2003). Personas: practice and theory. Proceedings of the 2003 conference on Designing for user experiences, San Francisco, California, ACM Press.
Ritchey, T. (2002-2006). General Morphological Analysis: A general method for non-quantified modelling, Swedish Morphological Society.
Robertson, S. (2004). Scenarios in Requirements Discovery. Scenarios, Stories, Use Cases: Through the Systems Development Life-Cycle. I. F. Alexander and N. Maiden, John Wiley & Sons, Ltd.**:** 39-59.
Rolland, C. and C. B. Achour (1998). "Guiding the construction of textual use case specifications." Data and Knowledge Engineering **25**: 125-160.
Rolland, C., et al. (1998). "A proposal for a scenario classification framework." Requirements Engineering **3**(1): 23-47.
Ronkko, K., et al. (2004). Personas is not Applicable: Local Remedies Interpreted in a Wider Context. Participatory Design Conference, Toronto, Canada, ACM Press.
Rubin, K. S. and A. Goldberg (1992). "Object behavior analysis." Commun. ACM **35**(9): 48-62.
Rumbaugh, J., et al. (1991). Object-Oriented Modeling and Design, Prentice Hall.
Schwartz, P. (1996). The Art of the Long View: Planning for the Future in an Uncertain World, Currency.
Shigley, J. E. and C. R. Mischke (1986). Standard handbook of machine design. New York, McGraw-Hill Inc.
Shin, J. E., et al. (2005). "Scenario advisor tool for requirements engineering." Requirements Engineering **10**(2): 132-145.
Suri, J. F. and M. Marsh (2000). "Scenario building as an ergonomics method in consumer product design." Applied Ergonomics **31**(2): 151-157.
Svanaes, D. and G. Seland (2004). Putting the Users Center Stage: Role Playing and Low-fi Prototyping Enable End Users to Design Mobile Systems. SIGCHI conference on Human factors in computing systems, Vienna, Austria, ACM Press.
Swartjes, I. M. T. and M. Theune (2006). A Fabula Model for Emergent Narrative. Technologies for Interactive Digital Storytelling and Entertainment, Third International Conference, TIDSE 2006. Darmstadt, Germany, Springer Verlag.
Tawbi, M., et al. (1998). L'ECRITOIRE a Tool to Support a Goal-Scenario Based Approach to Requirements Engineering, ESPRIT project CREWS N°21.903.
Tideman, M., et al. (2005). A Scenario Based Method for Product Design. International CIRP Design Seminar - "New Trend in Engineering Design". Shanghai, China,.
Tideman, M., et al. (2005). Using virtual reality for scenario based product design. Proceedings of Virtual Concept 2005. Biarritz, France.
Ullman, D. G. (1992). The mechanical design process. New York, McGraw-Hill Inc.
Watts, R. D. (1966). The Elements of Design. The Design Method. S. Gregory. London, Butterworths.
Weidenhaupt, K., et al. (1998). "Scenarios in system development: current practice." Software, IEEE **15**(2): 34-45.
Wright, P. (1992). "What's in a scenario?" SIGCHI Bulletin **24**(4): 11-12.