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Chapter 12.
Developing of Future User Interfaces

Matti Vuori, VTT Automation
Jouni Kivistö-Rahnasto, VTT Automation
Sirra Toivonen, VTT Automation

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12.1 Foreword: Development for the future

User expectations are changing and new technologies are advancing faster than ever. High quality user interfaces will be even more important in the future than today. Companies have many possibilities and needs for innovation in their user interfaces. An active company is able to lead the development of new concepts and to defend their existing products when necessary. A passive company only reacts when the change is already having an effect and it is lacking essential knowledge and resources. For the passive companies, development of new concepts and products is hopelessly delayed and then the markets are already filled up with the competing products. The active, future oriented company is decidedly ahead of others (Figure 12.1).

Figure 12.1. The future can be predicted.

When companies are struggling to keep practical designing going, under the pressure of limited resources, the use of extensive methods of futures research and procedures appears difficult. For this reason, methods of future research and methods of advanced product development have to be combined, based on the experiences from good industrial product development practices. Both new concepts and existing products have to be taken into consideration when integrating different approaches. The major challenges

are management of technological advances, foreseeing user needs, together with management of complex product information and risk management. Falling in love with technology is a serious hazard in the future oriented development.

For the companies, new methods alone are insufficient help. Product development culture must be build comprehensively based on product conceptions, attitudes and suppositions of the designers, manufacturers, service providers and marketers. New organisational ways of action are required. The development must be done on a higher level than in previous projects, because of the uncertainties involved.

This chapter presents modern ways of action and methods developed to facilitate companies

- to create new user interface concepts
- to modify their existing user interfaces to succeed in changing environment
- to evaluate user interfaces targeted for the future environment.

In this chapter we outline

- modern thinking necessary for successful development of interactive products and user interfaces
- some of the most fruitful modern methods for user interface and usability designing, and last
- special methods for developing for the future.

12.2 What is a User Interface?

12.2.1 A Simple Model of the User Interface

The user interface provides the means for the user to utilise the functions and benefits of the product (Figure 12.2). *Different user groups* can have their own user interfaces. The primary user group always has a specific user interface, but often the service personnel have a user interface, too.

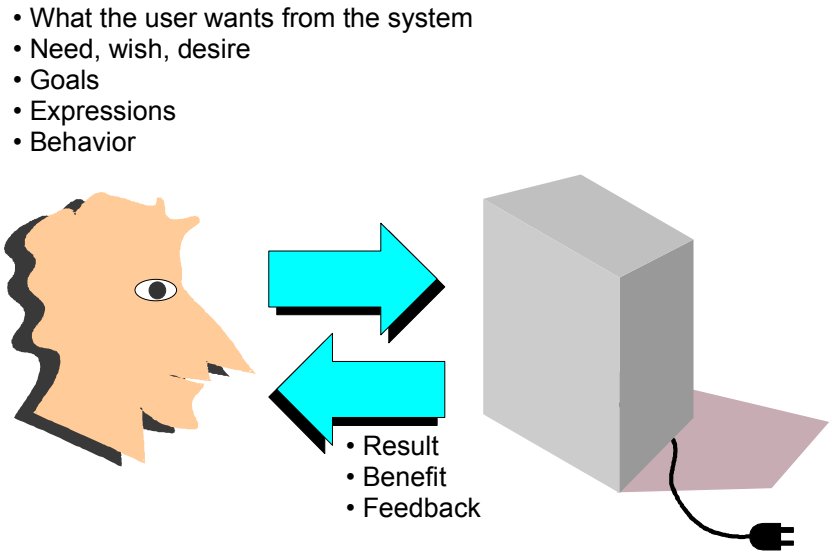

Figure 12.2. The user interface makes it possible for the user to get from the system what he/she wants, and to make the system behave as he/she wants it to.

12.2.2 Different Levels of the User Interface

Products have a user interface, which is based on *control and display components*. However, those are just a part of the user interface. From the *point of view of the use*, all the ways of using the product constitute to the user interface. That is, all the various ways of managing and controlling the system. From the point of view of product psychology, the user interface is everything the *product communicates to the user about how it can be used*. The entirety of the product, the semantics of the design, the matching of user goals and the purpose of the product all contribute to the user interface. When we consider: What is the impression of the product? What is the use experience? It can be said: *the product is the user interface*.

All different sub-products, modules and functions of the product can have a common or a separate user interface. The *formal user interface* means all the control systems, which the user either knows or is able to detect. For example, a car has a large number of controls used for a single function, or purpose, and they together are the driver's user interface.

The user interface components, controls are often collected to a panel or other visually separated part of the products. They are usually implemented as *components*, utilising some *technology* (mechanical, electromechanical, or programmatic technology), and they utilise some functional principle (Figure 12.3).

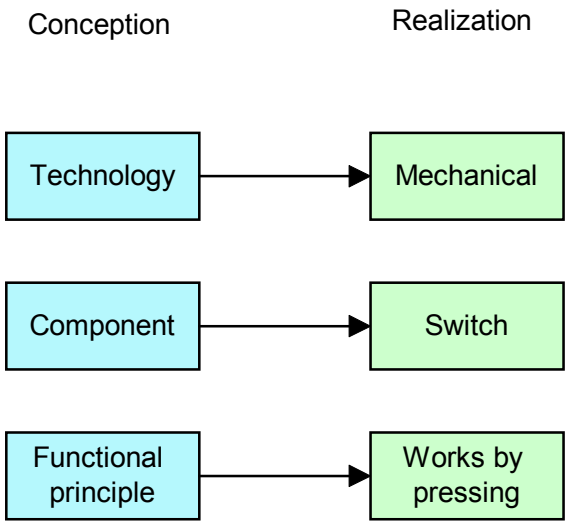

Figure 12.3. Conception and realisation of user interfaces

The user interface is characterised by a *style*. For example, a computer game and a milling machine have different styles and communicate different messages. The game is all about excitement, speed and challenge, whereas the user interface of a machine gives out messages of reliability, safety and quality. Some elements of the style are:

- Design
- Use of colour
- Graphics
- Control types used
- Perceived rationality
- Culture-specific clues

Because the user interface is all about communication and messages (Figure 12.4), a user manual and other user instructions are also a part of the user interface. The same applies to the packaging and markings of the product. However, in the language of everyday design, user interface most often means just the formal user interface components of the primary product.

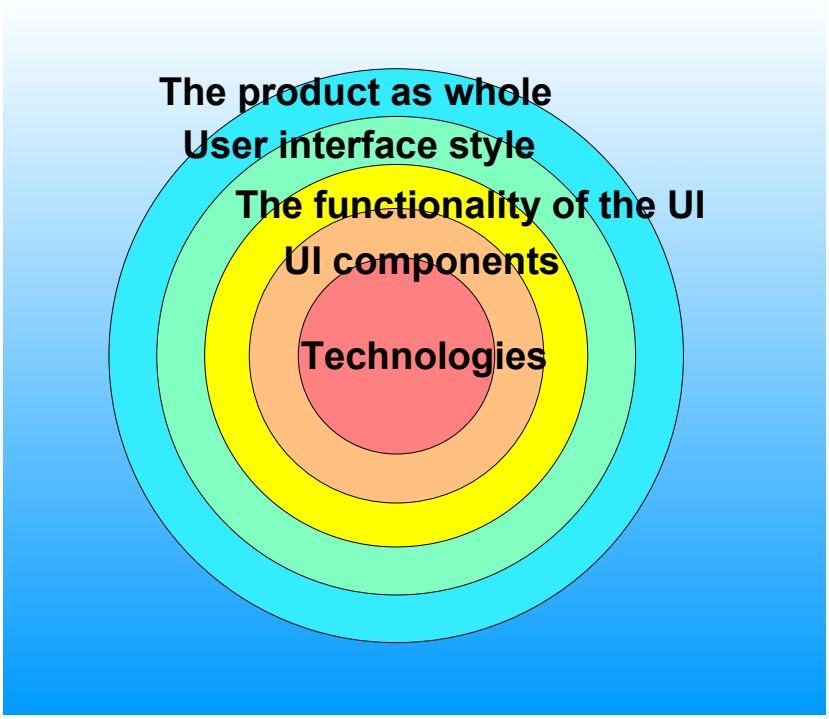

Figure 12.4. The layers of a user interface.

Th user interface can be located in various ways (Figure 12.5):

- in the product (device, machine)
- in a separate control unit
- somewhere in the workplace
- with remote control in another workspace, even in virtual space
- attached to the user
- as an accessory of the user
- and so on….

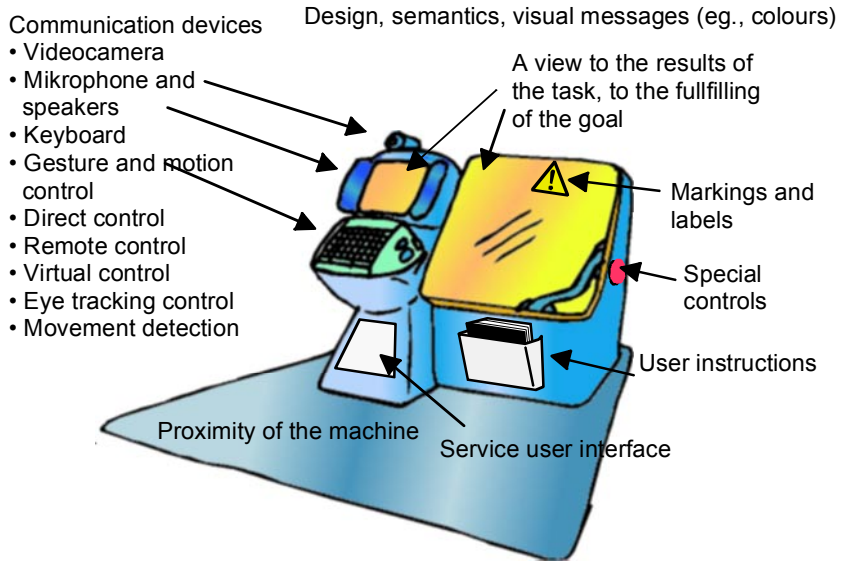

Figure 12.5. Concrete user interface components of a modern user interface.

As an example of a separate control unit, a remote control unit of a television is familiar to most people. Nowadays, a computer can often be used for controlling other devices. Controls attached to the user are starting to appear. Gaze controls and other such devices will be common in the future. Common virtual reality user interface elements are visors or eyeglass mounted displays. In a virtual user interface, some aspects of the product and the use of it are modelled in 3-D, and the activity happens in simulation. The product can be presented to the user as a virtual model on a computer screen. Instead of pushing real buttons, the user pushes virtual versions, implemented on the computer. The user can be virtually modelled too, and can meet the product in a virtual world, using the virtual product with his/her virtual body, capabilities and senses.

A user interface concept is a conceptual model, which combines all the features and solutions, which determine the user interface, or what clearly differentiate it from others.

12.2.3 The Relationship between the User Interface and the Product

Table 12.1 illustrates the relationship between the user interface, the product as a whole and the task for which the product is used. The rows in the table provide viewpoints to the task and the product. The columns represent various levels of the relationship, starting with what can be perceived of the product and ending with the level of goals and principles of the task.

Table 12.1. The main viewpoints of use tasks and the product divided into various levels

Element	"This is what it is like"	"This is how it works"	"This is how it is used"	Needs and other basics of the task
Task	• What controls are used, to use the product? • What (technical) functions do they control? • What results and benefits do they control?	• How do the controls work? • Why do they work that way?	• What is the general way of usage – states (modes)? • Does it match the user's mental model of the process which he/she controls?	What is the task as a whole?
Information	What devices are used to control information / knowledge / data?	• How it the information presented? • In what form is the information presented?	• How does the user handle information in his/hers task or work? • What information is managed by the system and what by the user? • How is the information concerning the goals of the task managed?	• What information is needed to do the task? • Where can the information be obtained?
Management of the situation	What alternatives exist for doing the different functions and subtasks?	• Is the user free to choose the way he/she works? • What can go wrong?	What is the cooperation between the user and the system like?	Who is the boss? Do we act on the preconditions of the user or the system?
The presence of the product	What can be seen, or perceived by other senses, of the product?	• What do the perceptions tell? • What does the product tell about itself and its purpose? (What does it belong to, what can one do with it?) • What does the product "propose", what does it "forbid" and repel?	What is the relationship between the perceptions and user's goals and tasks?	What is the relationship between the perceptions and user's need, wishes and dreams? (As a user and as a human being)
The relationship between the user and the product	Do the product design solutions please and suit the user?	Do the ways of using the product suit the user (aesthetically, ethically…)?	Does using the product fit into the user's culture?	Do the goals and values of the system match the user's goals and values?

User's Senses and Interpreters of the User Interface

When the user first meets the product and when he/she uses the product, the event is guided by the user's senses. Table 12.2 lists some connections between the senses and the user interface.

Table 12.2. Some connections between the senses and the user interface.

Senses	Corresponding elements of the user interface
Sight	• Design • Colours, pictures • Luminance • Perception of the formal user interface – the designated controls • Markings and labels • Instructions, manuals
Hearing and speech	• Speech control • Audible warning signals and messages • Sound of the process (how the machine "sings", what is the condition, what is the phase)
Sense of touch	• Controls, switches • Vibration • Location • Temperature of the parts • Air flow • The sense of being in the machine, of in the close proximity of it (body sense) • Pressure
Sense of smell	• The smell of the machine or its surroundings • Smell machine in virtual devices
Sense of taste	• Taste machine in virtual devices
Balance	• The sense of being in the machine, of in the close proximity of it (body sense) • Pose, posture

12.3 The Elements of Quality of a User Interface

The main function of a user interface is to enable the user to perform tasks on the product and to reach his/her goal with the product. This means that the interface must have all the required functions. They must also be implemented in a way that the product is usable. This means that the usage of the product must be productive, safe, easy to learn and reliable, just to mention a few criteria. The design should be based on the needs of the users. The designers need to know what kind of people the users are, how they really work with the product, what are their preferences are? With today's products it is hard enough to try to meet these criteria. When designing tomorrow's products, the challenges of meeting the needs of future users is even greater. Designing the user interface and designing the whole product and the system where it is used are inseparable.

One aspect which is sometimes neglected, is the desirability of the user interface. With today's products, the interface is often the face of the product. Sometimes the interface characterises the product more than any other component. Contrary to what the users might claim during interviews, looks do matter. Visual preferences develop within the culture and cultures change. We must take into consideration what the product communicates with its look and feel. Companies are not always aware of what their brand messages are – and what they should be. Products give messages about durability, friendliness, safety and advancement with very subtle clues. Many products live or die with these messages.

The needs of all interest groups must be considered and weighted during designing. The sales chain is very important for many products. To be marketable to the sales chain, the interface needs to have the following qualities (among some others):

- Good brand representation
- Newness and innovativeness
- Easiness to demonstrate the value to the customer
- Easiness to train to the users
- Cost efficiency
- Low support needs

Lastly, the company must be able to manage the user interface technology. Companies are always tempted to use the sexiest technologies available. However, implementing them solidly in the product range is difficult and takes resources. Choosing new technology requires investment in usability, desirability and safety designing. The risks of new interface types are plenty, but so are the benefits, if the designing is done with good risk management.

12.4 Modelling the User Interface

12.4.1 Modelling the Product Conceptually

The conceptual models of the product include operation product concept, function model, construction model and quality model. The *operational product concept* is a new concept. It describes the product as a combination of all the relevant elements of usage. The same elements are essential for developing the user interface. The *function model* describes the functions of the product, their values and most important quality factors for the user. The *construction model* describes how the product is divided into sub products, modules and parts. Attached to each of these models is a description of how they work, for what purpose they exist, and what the most important quality factors are. The *quality model* is an analysis of the success and quality factors of the product.

12.4.2 The operational Product Concept

Different occupational groups perceive products in various ways. Marketing may have a needs and wishes based view, whereas designers may see the product as a technical entity. The company's management may see it as an economic enterprise. However, modern product development needs a common conceptual model for a product. The model has to be common to all parties participating in the development. A comprehensive model named *"operational product concept"* captures the essential features of a product from the viewpoint of how the customers will use it. The same viewpoint is essential for user interface development (Figure 12.6).

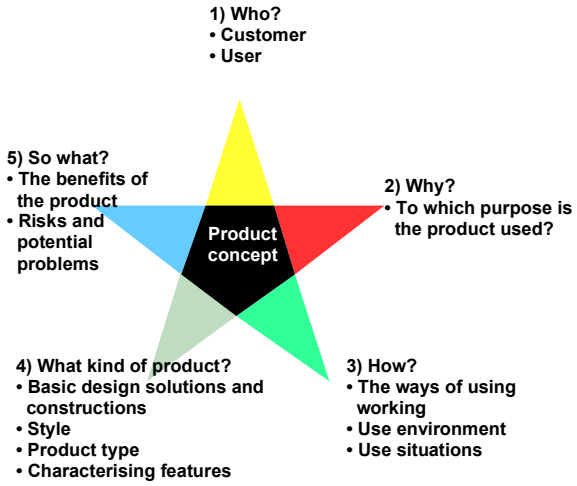

Figure 12.6. The operational product concept.

At conceptual level, the operational product concept presents a framework for discussing the essential elements of a product concept. It can also efficiently visualise them. It allows the description of a product or a product concept in a nutshell. The elements of the concept, shown in Figure 12.7, can be presented in a table where the star in the centre is replaced with a photo or a drawing of the product, and the elements are described with text boxes. This conceptual model has been in use in many projects and has proven to be an efficient new way of building a common vision for product development.

12.4.3 Modelling the Use

How the general system works, what the people do and how they think about their tasks are the basic questions, that have to be answered before and during the designing of the user interface. This way of designing makes it clear that development of the product concept and the user interface concept cannot be separated (Figure 12.7). One cannot develop the "product" first and then the interface, or otherwise design them separately.

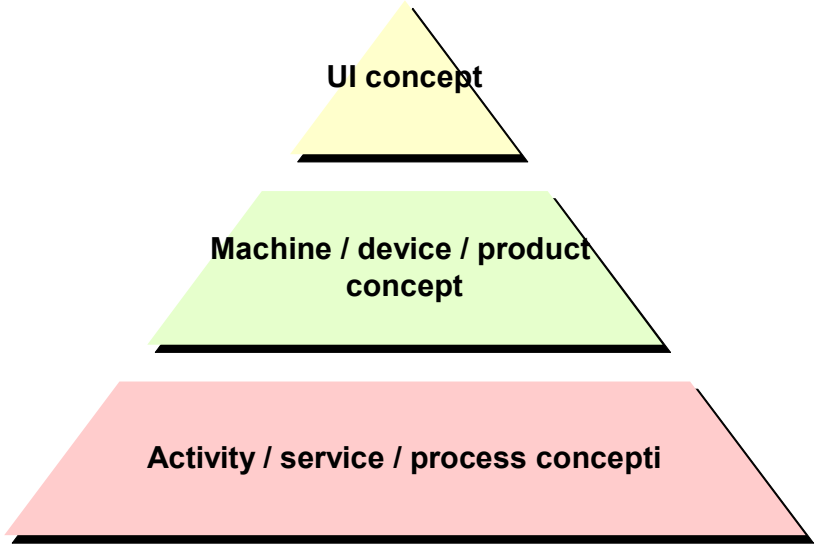

Figure 12.7. The user interface concept must be based on the product concept.

We need to know the users and the preconditions on the work or other usage system. There are many methods for determining this. Depending on the development situation, the following tools can be used:

- Interviews
- Focus group discussion
- Surveys
- Surveys and studies of competing and previous products
- Observation and analysis of the activities

However, to analyse the situation properly, we need to model the usage system with a conceptual model that gives the developers a common model of the target system and the product. This type of modelling does not lock the developers thoughts and provides a solid framework for development under which creativity can be used. With such modelling, the product can be studied on a suitable abstract level, preventing us from getting stuck on little details. When designing a user interface concept, this is most important. Modelling also helps us to talk about issues which have become too common for some parties – the world changes and old suppositions must be challenged. The models used can be divided into product- and usage- related models.

The more we aim to change our concepts or aim at new markets, the more important modelling is. It helps us to find new needs and new ways to utilise new technology efficiently.

The modelling during the first phases of product development should cover the user tasks, usage environment and the users. The modelling process needs to be done in co-operation with all the organisations that know something about the use. In the essential position are the people who have frequent contact with the users and the client companies, because they have knowledge of the users' needs and problems. Sales and service organisations are examples of these. The people who are making the models must pay visits to the users sites to find reliable information on how the work tasks are actually done. The tools used are observation and interviews. There are simple tools and data collection forms available for this. The modelling should always be based on generic models. For example, there are generic models of how work tasks are divided into phases and how what elements constitute a machine system.

The models which describe the use include task model, environment model and user model. In the *task model,* the task is divided into phases, actions, and their analysis. This way the modelling turns naturally into task analysis. The model describes the goal of the user, how the user does each step, what the alternatives are, what the needs are, what the problems are and so on. Understanding the overall goal and the goals of each step helps to understand the user's tasks and his/her real action in for example disturbance situations. When using task and context analysis we discover new ways of acting with the new products and their user interfaces. We can synthesise new ways of action, create new scenarios and "use cases". However, this knowledge is now based on a solid understanding of the reasons behind the proposed activity.

With the *environment model*, the user's environment is modelled. The physical environment includes the climate, other natural environment, and the built surroundings. The social environment includes the working community, organisation and technological environment. The cultural environment includes nationality and ethnic issues and the corporate culture – peoples common beliefs, suppositions and ways of thinking and acting. One important result of the environment modelling is the creation of client organisation or company segments. Segmentation of client companies is most important when developing business-to-business products.

The *user model* describes and classifies the users during all phases of the products life cycle. The primary, secondary and indirect users are determined. The most characterising features are determined, as are special features, skills and knowledge and personal traits. They are analysed for all user groups. Classifying the primary users into groups is called *user segmentation*. This helps greatly in designing products and user interfaces for a given type of users. Lastly, the segments are prioritised. This helps to target the product functions and features. The criteria used in prioritising include:

- Size of the segment
- Potential of the segment to became users of the product
- The risks of the segment becoming users

The usage of the methods described above is easier if we have, at least, a preliminary concept. We need some concept, at least, a "black box" to talk about the product and to visualise the usage. Visualising helps us simulate situations which do not exist or which we have not seen ourselves. Visualising and simulations aid in finding the most critical requirements of the new product. The product vision has to be shared between people from different occupational groups, and that simply cannot be done without some visualisation. Requirement lists or lists of specifications do not communicate the product vision efficiently enough. There are many ways of visualising the concepts.

12.5 Designing a User Interface as Part of Product Development

12.5.1 The Competences Required in User Interface Development

Various competences are required in the development team. It is clear that knowing the technology is not enough. Nor is usability expertise sufficient. We need to build a team with diverse abilities and viewpoints (Figure 12.8).

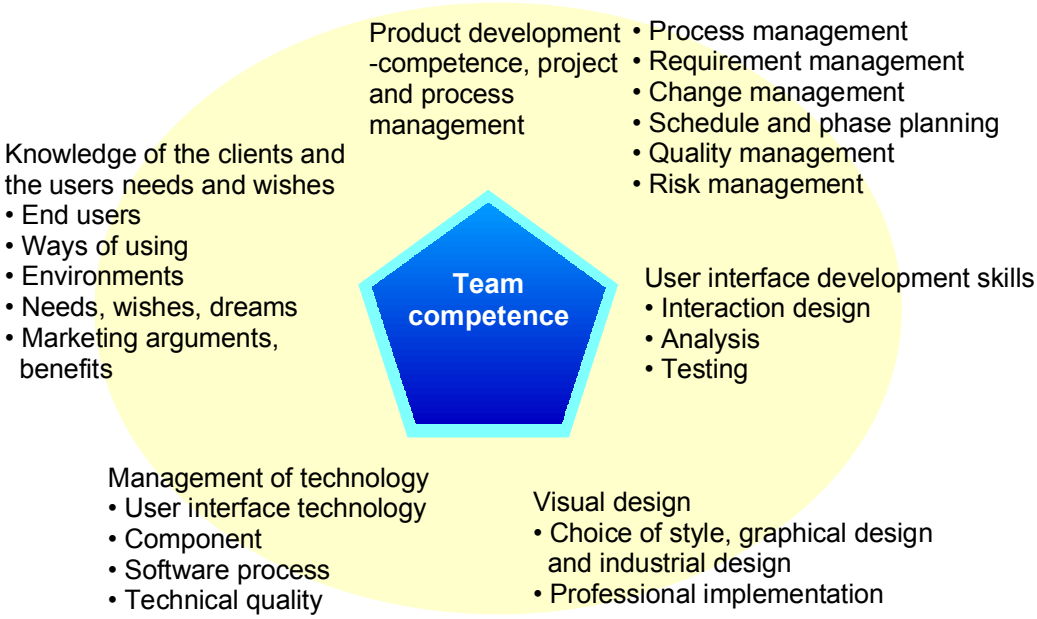

Figure 12.8. Key competences of a user interface development team.

12.5.2 The Development Process

Development of a user interface is always a result of some kind of process. In many cases, the process may be loosely defined, and even chaotic. Everyone may think of it in a different way. On the other hand, in some cases the process may be too tightly controlled, and not give space for variation needed in different development situations. Typically, interface development starts with the ideas and needs and formulation of the requirements for the interface (Figure 12.9). The design is started in the conceptual level, but the concept and the preliminary ideas are simultaneously visualised. During the development, the implementation, simulation and testing are carried out on the basis

of the concepts. At the final design stages the user interfaces and related documentation and aftersales activities are finalised (Table 12.3).

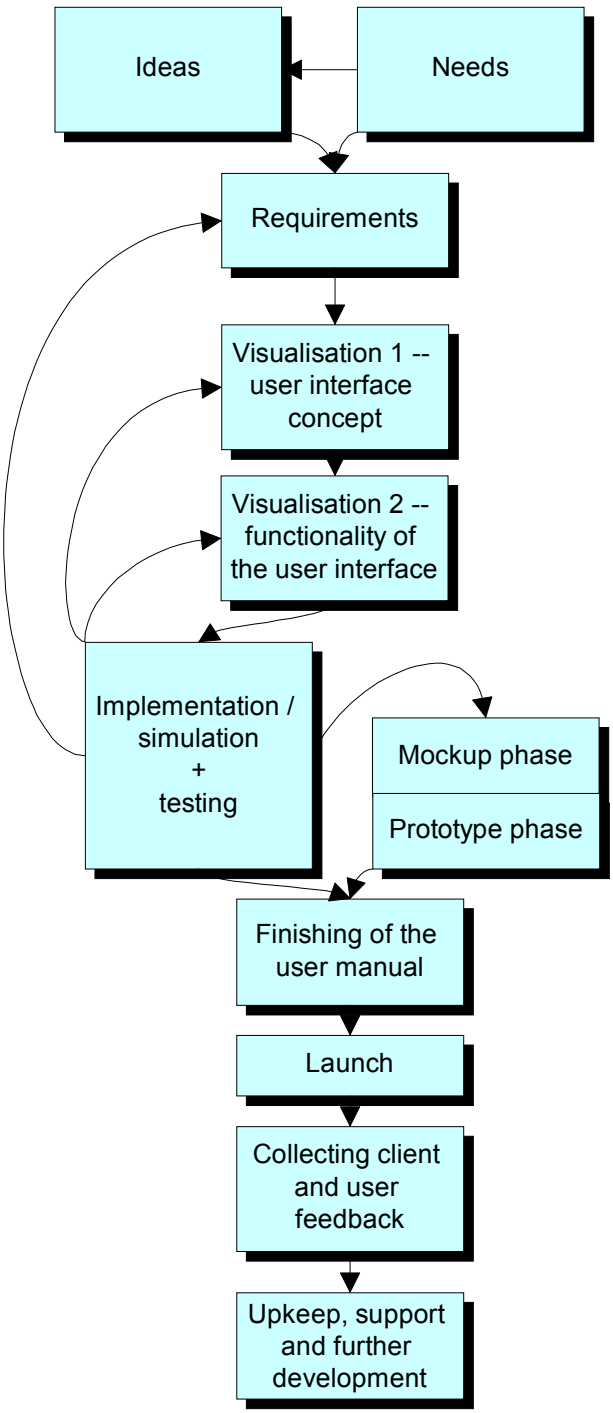

Figure 12.9. A basic model of the systematic user interface development project.

Table 12.3. The phases of the systematic process of user interface development.

Phase	Description
Ideas	Creation of new ideas is an innovative starting point to a new product. Ideas can be created in many ways
Need	Often the basis for development is a need noticed in the market
Requirements definition and preliminary concept	The requirements definition builds a common vision and contract of what we are developing, for whom, for what purpose and with which benefits, but it should not contain specific technical solutions. Segmentation, modelling and analysis, and preliminary visualisation are important tasks and techniques here.
Visualisation and demo-phases	• The basic concept of the user interface is designed, documented and approved (functions, panel type, visual style, etc…). The designs are visualised with e.g. drawings and diagrams. • The concept is evaluated analytically with multiple criteria. Many times, a couple of alternative concepts are designed, and compared, and then the best is chosen for development • The functions on each product (or user interface) of a product family is decided on, using a function / product matrix.
Prototyping	• The user interface is prototyped on a computer with, for example, ToolBook, Director or Visual Basic -programs. User interface solutions are designed, presented (demoed) using rapid prototyping techniques. • Prototypes are analysed with formal methods using heuristics, simulations or expert evaluations.
Implementation / simulation	In the implementation phase detail design and coding is done, and the user interface is moved to the final programming environment.
Mockup phase	• In the mockup phase, the user interface works in a simulation environment on a PC, or/and in an old product or a mockup on the new product. • A mockup of the whole product makes it possible to use the product (in a limited way), or to simulate the usage. Good simulations of usage situations and preliminary user tests can be arranged. • Analytical analysis methods are used heavily • There may be a draft of the user instructions available.

Phase	Description
Prototype phase	• In the prototype phase the user interface works in the prototype of the product. • Most design solutions and decisions are made. The aim is to accept them – but still find the needs to fix errors and deficiencies. Components may well have been ordered already and production planned, so big changes would be costly. • To find problems, usability tests and safety analyses are carried out.
Finishing the user instructions	• A user manual is usually finished after the rest of the product. • User documentation is evaluated with formal methods (often a checklist) and they should be tested.
Launch	The product is launched to the market
Upkeep, support and further development	• The user interface is further developed (especially, if it is software based) if needed for updates or new versions. • New software releases are planned and developed

The development process has many general features. *Iteration* – returning to previous phases with new insight – is always important when developing interactive products. The *design–implement-evaluate-cycle* repeats in small and larger scale. Designs and facts are assessed more than in audits. In formal evaluations, it is important to change viewpoints, methods, and to look at designs from the actions and user's perspective. In addition, remember that products are not equal. Different products and product groups have varying success factors and requirements. With some products and user interfaces, desirability is the most important theme in design and in analysis, whereas with other products, safety and error tolerance might be the essential feature. *Usability tests* are carried out in several phases (at least two), in a way that the results are usable in development.

The beginning of the development process is critical, because the concept must be fixed, and the most determining decisions must be made. Changes at a later stage are costly.

Typical mistakes in the early phases are:

- Needs of the users and clients are not known
- The users and the real ways of using the product are not known
- The users are forgotten after the preliminary studies
- Only the primary user segment is considered – the biggest problems and greatest product liability risks can be caused by segments outside the main interests of marketing, or in unexpected situations or environments
- The definition of initial information for the design, may be deficient
- Commitment to certain design solutions are made too early (for example, some user interface components)
- Alternative concepts are not created
- No real multiple criteria decision making is done
- No designing is done at early phases, just "specification"
- The conceptual understanding and managing of the product is deficient – even the word "concept" may be unfamiliar. This causes concentration on technical issues and components
- Lack of faith – the concept is believed to be fully developed, no more room for improvement
- Only some occupational groups are included during concept development. Even an industrial designer may be lacking, and only brought in later to give forms to the product
- Usability experts are not used at concept development
- There is no risk analysis of the problems in implementing the concept in-house, which is important when changing technologies

12.5.3 User-oriented Requirement Specification

The term requirement specification has three meanings:

1. The process of specification

- The descriptions, modelling, studies, discussions, deals, ideations …

2. The collective agreement

- Agreement on what we are developing, under which conditions. Building the vision, development of the vision, agreement, documentation
- What is expected, wanted and required from the product
- What are the quality and success factors of the product

3. The document which describes the agreed-upon requirements

- The entry of the collective opinions
  - Client – supplier
  - Different parties of product development process
  - Management – product development project
  - Inside the product development team
- A dynamic view, a changing document
- Content:
  - The concept
  - Goals
  - Initial information
  - The known needs and requirements of all parties
  - Preconditions and limitations (eg. standards, self imposed limitations)

The requirement specification is not a phase which precedes designing. It is serious designing. Creation of the requirement specification is a critical co-operation phase, mostly between marketing and product development organisations. Sometimes the requirement specification starts the preliminary design phase, but sometimes the requirement specification ends the preliminary design phase, and starts a more committed and concrete development. However people utilise this phase, it is of great importance that they do it knowingly, understanding the development process they are utilising. And it is important to remember that the requirement engineering process is often more important than the resulting document.

The following information should be included in the requirement specification document:

- General description of the product
- The purpose of the product
- Clients and users
- Use situations
- The needs of the client and users
- Competition
- Benefits
- Guidelines for the development

12.6 Most Important Methods of Ensuring Usability

Usability is the result of the whole development process. Usability designing is an advanced skill, which needs proper organisational support and a solid development process in order to be successful. Usability is not granted. Usability must be required and requested. Otherwise, nobody designs it. Good designing requires know-how and skills. The developers must be well trained for usability, and the whole organisation must have such a knowledge level that they can co-operate in designing. Common goals, language and mental models of the product developed are a necessity. For the designing, the developers need reliable information from which to create a product synthesis. This information includes descriptions of the user and usage.

The designers must use good guidelines – standards and heuristic rules. The development must be guided dynamically and new insight must be gathered continuously. This is because interactive systems can never be understood fully at the beginning. As the development progresses, we get more information and experience, and the opinions necessarily change. The designs must be verified using both analytical and empirical methods. In this section, we briefly present a couple of the most important methods for verifying the usability of a design.

12.6.1 Heuristics

Heuristics are rules of thumb, created from practical experience and from human factors analysis. They outline good general characteristics of systems and user interfaces. Therefore, heuristics can be used in many ways for training the many occupational groups who participate in product development, assessing concepts and drafts of user interfaces, assessing implemented user interfaces, and as a guideline for designers

Although compilations of heuristics have been published for decades, the usability culture has created some new sets of heuristics which are fruitful for assessing modern devices and systems. These heuristics are published by Nielsen (1994), and are mostly suitable for programs used in an office environment (Table 12.4).

Table 12.4. Usability heuristics by Nielsen (1994)

Ten Usability Heuristics
Visibility of system status
The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world
The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom
Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards
Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention
Even better than good error messages is a careful design which prevents a problem from occurring in the first place.
Recognition rather than recall
Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use
Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalist design
Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Help users recognize, diagnose, and recover from errors
Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation
Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

To complement Nielsen's heuristics, we have added the following:

- Coupling of controls to each other and to product's function
- Suitability to the environment and to the user
  - Considering for example size of text and displays, luminance, positioning
  - Using different controls
- Build to the task
  - Navigation, menu structures, order of using the functions
- Adaptability
  - Non-modality
  - Tasks can be carried out in various sequences

These heuristics are for the user interface level. We have another list for the designing level. It can be used most fruitfully during the early stages of development, where it has a guiding effect not only for the product, but also for the process. The list is currently available in Finnish only (Vuori & Kivistö-Rahnasto, 2000a).

12.6.2 Checklists

Evaluating the usability of products does not always have to be a heavy procedure. A carefully designed checklist for analysing the user and task characteristics is a practical tool for carrying out quick evaluations during designing.

What is a checklist? Is it not just a list of items, to be literally checked (with a check-mark) when inspecting something? No, there is more to checklists than that. A checklist presents knowledge regarding a product. Someone has defined the listed items as meaningful properties of the product. In addition to that, they are meaningful in a context — for the use of the product, and for the use of the list. Checklists can be used for:

- *Orientation*: these are important aspects of the product!
- *Guidance*: when designing, do these properly!
- *Inspection*: when done, have these been done properly?
- *Quality control*: these items are checked: It should be okay!

Checklists have traditionally been built around the static features of a product, like display layout, text sizes and so on. It is obvious that a successful usability analysis needs two dimensions:

- Checking for adherence to good structural principles (covering all situations of use)
- Checking for the requirements arising from the situations where a product is used.

Making the checklists specific for product groups allows these two simultaneous functions:

- Concrete: more concrete than a list of general heuristics, like ”make it easy”
- Open: allows product concept development, since the checklist is not fixed to specific design solutions
- Versatile: can be used for an entire product family in the company, and works in every phase of product development and design.

Example Checklists Based on Tasks or Features

The product specific checklist for the physical ergonomics of a workout device and the checklist for usability of packages are based on tasks. In these checklists, all tasks during the whole lifespan are systematically evaluated (Table 12.5). Similar checklists are developed for welding machines (Table 12.6) and user instructions of machines. The checklists incorporate common stylistic guidelines, as well as items involving the users and use, and information on the requirements in standards.

Checklists provide real benefits to the usability consultant in client assignments. Checklists serve as quality control for the expert and as a communication device with the designers. However, expert evaluation is only a part of a usability assessment, and using checklists is only one tool for it. At least, user and task analyses and some usability testing are required almost without exception.

Table 12.5. The topics of two task-based checklists.

Checklist for the physical ergonomics of a Workout device	Checklist for usability of packages
Assembling and setting up at home	Packing the product
Stepping in the device	Moving the packed product
Starting and stopping	Transporting the packed product
Keeping balance, staying on the device	Receiving and storing the product
Operation	Handling the packed product
Adjusting	Unpacking the product.
Maintenance	
Surfaces	
Requirements on user equipment	
Hazards	
Maintenance	
Moving the device	
Storing	
Others (specific to the device)	

Table 12.6. Topics of the usability checklist for the welding machine user interface

Checklist for the usability of a welding machine's user interface
Physical ergonomics of entire machine
Physical ergonomics of control devices
Physical ergonomics of display
Visualisation of information
Instructions and system help
Man-machine interaction
Hazards and signals
Learning how to use
Protective clothing
Maintenance

12.6.3 Analytical Simulation

The real working of a product must be simulated as early as possible. This does not mean simulating the internal processes of a machine, but instead, we want to find how the real use situations happen. In other words, how will the real users – in the future – really use the product? Product designers do not know that. Designers may think of some ways to use a product and suggest them, but people and people-machine-systems do not work as designers suggest. People work in ways that suit their situations.

Of course, real life experience – from tests and from practice – would tell how the usage would happen. However, we cannot wait that long. Once the system is testable, many decisions have been made, money has been spent and changes are too costly. Thus, we need to simulate the use analytically. The methods of task analysis are based on the idea that we model the task sequences to subtasks and actions. This can be done by observing users, but it can also be done by using general models of tasks as a basis and then thinking about how the user – based on what experts know about human behaviour – would behave. What would he/she do? What controls would the user need to use? Would there be any problems in choosing or using them? Possibilities of human error and accidents must be found by thinking – we can not wait for real life proof of the dangers! A method based on these ideas is used at VTT Automation. It is called "Usability and safety analysis of use task of a product" (Figure 12.10).

Usability and safety analysis of use task of a product Product:	Page: 2(2) Analyst:

Task (or subproduct):	Date:

Task phase • What does the user do	Observation • Problem • Danger [• Positive observations in square brackets]	Causes of the problem • Misuse, human errrot • Deviciency in product, hazard • Lack of information (And so on...)	Classifi-cation Severity of the problem	How often / how many users suffer from the problem	Remedies. Eg: • Design changes • Better markings • Better instructions

Figure 12.10. The form used in method "Usability and safety analysis of use task of a product".

12.6.4 Usability Testing

Formal testing of how a prototype or implemented product works when used by real users is called usability testing. The testing is carried out in a controlled environment and consists of the following main tasks:

- Definition of the purpose of the tests. Are we making the tests to get development ideas, to test for compliance to some specific criteria, or just to determine whether there are some problems with the use.
- Analytical studies. Usually we carry out some analytical evaluations to analyse some hypothetical problems, which we want to verify whether they are a real problem or not.
- Definition of the task and user segment(s) to be tested.
- Building the test environment.
- Preparation of the test forms, checklists etc.
- The test session
- Analysis of the results, priorisation of the findings and communicating them to the design team.

The arrangements of the test site include closing the site. We must not allow people coming to disturb the test. If the test is not carried out in a modern usability laboratory, space for people watching the test must be prepared in some corner where they do not disturb the test persons. The roles and rules of conduct must be agreed on with everyone participating in the test session. Someone will be chosen as the director of the test. Only the test director talks with the user. When there are problems, the test director can ask for assistance from a designated support person. It is important that others, such as designers of marketing personnel remain quiet during the whole session. Someone is in charge of recording the findings, while another person (if available) will take care of the video and still cameras.

The test session starts with a careful presentation for the test users. The purpose and rules of the test are explained. The important rules to be explained to the user are:

- We are testing the product, not the user. If there are problems with the product, the product is at fault and will be developed. We really are looking for potential problems and other possibilities to make the product better. The user should not take them personally.
- If the user should get anxious, he/she can interrupt and end the test at any time. No questions will be asked.
- The test is fully confidential. The user must not tell anyone about the experiences (unless agreed otherwise), and the user will remain anonymous (unless again agreed otherwise).

Written permission to make a video and to take photographs is asked. The test environment, the test product and accessories are introduced, as are the test personnel present. Then, the test user is interviewed. The product is often introduced to the test user in a

short way – like a sales presentation. With this we seek a demanding real life scenario, where the user really does not know how the product works, and the first task is to find it out during the first trials.

In order to discover the problems, the test is observed and the test user will be asked to "think-aloud" about what he/she is doing and why, what the problems are, and if he/she is stuck. The thinking-aloud is first taught to the test user by demonstrating it.

The test phase starts with giving the test user a task to perform independently. Depending on the purpose of the test and the product, and the task at hand, the test task can be a full user task or just a phase of a task. The test user starts performing the test. He/she will not be helped unless he/she is stuck. Then, the problem will be explained and the testing will continue.

This procedure is repeated for a number of subtasks. After the test phase, the test user is interviewed. During the interview the problems are discussed, previously prepared questions about the product features and components are asked, and finally the user is asked to assess all the quality factors of the product, classifying them on a scale, like 1-5.

Then the test user is thanked, a possible remuneration is given, he/she is guided out of the test space, and the next session with a new test user is started.

The test volume does not have to be large, when complemented with analytical methods. Often the practical limits are imposed by how many users can be tested during a day (for first tests) or two (acceptance tests).

Sometimes the test videos are edited to show the most important findings. In most industrial projects, there really is no time or need for videos. When presented properly, the findings are clear to the designers without it. It is recommended though, that some designers come to watch the tests.

For further information see Dumas & Redish (1993) Vuori & Kivistö-Rahnasto (2000a).

12.7 Future-oriented User Interface Designing

12.7.1 Introduction

A good user interface is a necessity for successful products in the future. Rapidly changing user expectations and technologies challenge companies to compete with innovative solutions. The future-oriented companies are decidedly ahead of the followers. However, the usage of methods of futures research and procedures has appeared difficult for companies. VTT Automation has taken the challenge to combine the methods of futures research and the methods of advanced product and user interface development so that they supplement good industrial product development practices. The result is a methodology and toolbox of practical methods applicable to different fields of industrial development.

12.7.2 Approaches to the Future Studies

Pasking (1997) suggests that people have three ways of thinking about the future. A person having the fatalist approach keeps his/her head down and hopes that the future is favourable. A person having the rapid response approach tries to be as flexible as possible and tries to adapt to the changes of the future. A person having the purposeful approach defines what is the favourable future and ensures that it happens. The advanced companies have the possibility to make the favourable future happen.

The future can be studied on the basis of three paradigms (Mannermaa 1991)

- the descriptive paradigm
- the scenario paradigm
- the evolutionary paradigm.

The descriptive paradigm assumes that events in the future are predictable. The technology forecasting is a typical example of the descriptive paradigm. The main problem of the paradigm is the ambition to define probabilities of the events of the future, which is difficult or impossible.

The scenario paradigm aims to create alternative scenarios about the future. The results facilitate the present decision making. Typically the scenarios describe both desired and the threatening future circumstances and chains of events. The scenario paradigm is widely applied in the strategic business management of companies.

The evolutionary paradigm considers human activities to occur in systems which are dynamic, non-linear and far from the thermodynamic balance. The evolutionary paradigm is applied in studies concerning societies.

Practical methods for futures studies in technology are developed on the basis of these paradigms. Methods and taxonomies are presented by Coyle (1997), Watts and Porter (1997), Slaughter (1996), Koskela and Seppälä (1983) among others (Table 12.7).

Table 12.7. Analytical and subjective methods for analysing the future.

Analytical methods	Subjective methods
Analysis of patents	Journey of exploration
Analysis of publications	Novellas and prophecies
Analysis of history	Science fiction.
Analysis of errors and blunders	Focus-groups
Analogies	Interviews
Morphology	Questionnaires
Analysis of research activities:	Straw polls
- Basic research	Scenarios
- Applied research	
- Development	
- Applications	
Social consequences	
Growth and trends of publications	
Technological issues and discussions	
Maturity of issues and discussions	
New technologies on the basis of application	
Analysis of cause and consequence	
Interrelation matrix	
Trend extrapolation	
Correlation	
Simulation	

12.7.3 Developing Concepts of Future User Interfaces

The operational environment of future products and user interfaces is three to ten years from the present or even more. The future users, their needs, values and desires or tech-

nical or social possibilities and restrictions are not known today. Therefore, today's suppositions regarding the product and its use need to be challenged and reconsidered. Future needs differ from the present and call for a dynamic product development attitude. Product development has to be prepared for continuous changes in the operational environment, user needs and new possibilities in product designs. Here we outline the most important elements of these phases (Figure 12.11).

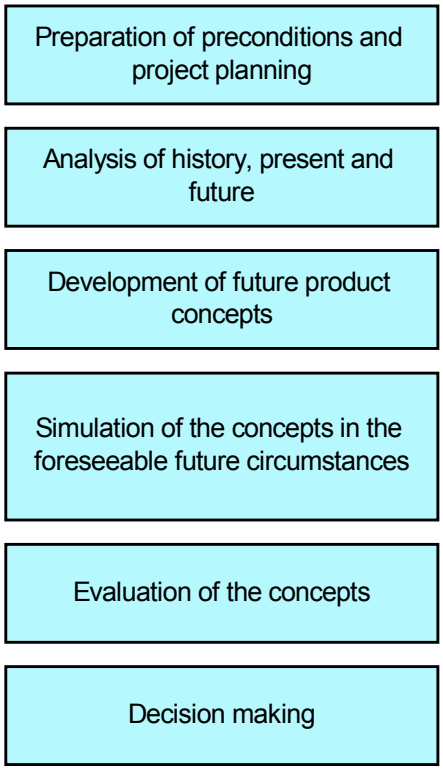

Figure 12.11. Phases of the development of the concepts of future user interfaces.

Preparation of Preconditions and Project Planning

Development of future user interfaces is strategic in nature. The design team must have clear understanding of the differences between the development of present interfaces and future interfaces. The development team must have sufficient motivation, competence and resources to clarify project objectives and common rules and to carry out the project planning and execution. In addition, a future-oriented development project lasts longer and requires more careful management than traditional development projects. The preconditions do not necessarily exist and they must be created. Commitment of management and development teams to future-oriented development is a necessity for successful projects.

Analysis of the History, the Present and the Future

The analysis of the history, the present and the future aims to stretch perspective to the future. To meet the future we need to understand the reasons for the present situations. The present needs and possibilities may change or fade away and new needs and possibilities may appear. The possibilities are not limited to technological advances. They also cover economic, social and ethical issues as well as users abilities, capabilities, needs, desires, and so on, that enable or restrict the development of product concepts and user interfaces.

In many cases, it is impossible to make quantitative predictions about the future of the existence or the states of the factors. This uncertainty needs to be managed during the design of the user interfaces of the future. The uncertainty can be managed by building up alternative scenarios about the future and by comparing the scenarios with actual events (Figure 12.12). The course of events provides information about the future, decrease the uncertainty concerning the future and affirms a specific scenario. The scenario provides an early detection of the most plausible future development. It is also important to extend the scenarios to the concrete action scenarios of the usage situations: how will the users hypothetically act? The scenarios of the users and the use of products lay the foundation for the development of user interfaces for the future.

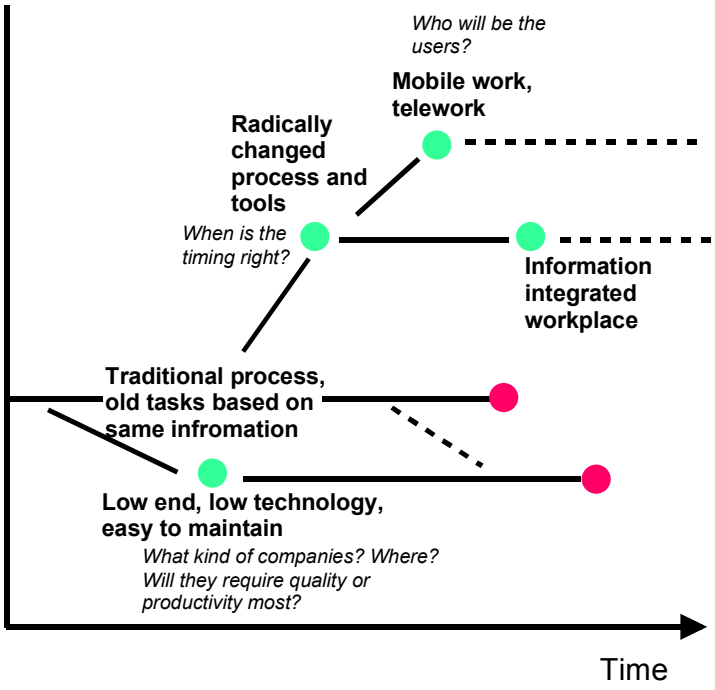

Figure 12.12. Alternative scenarios for a machine manufacturer.

The factors acting on the future can be identified on the different levels of generality (Figure 12.13). The general trends concerning the global development, the environment,

politics, societies and peoples provide important background information about the future. The industrial trends reveal product and production technologies of the future and the content of products. The trends concerning customers focus on activities, problems and needs of the customers in the future circumstances. The trends also cover social and ethical issues and peoples values, as well as users' abilities, capabilities, desires etc. that enable or restrict the development of product concepts and user interfaces.

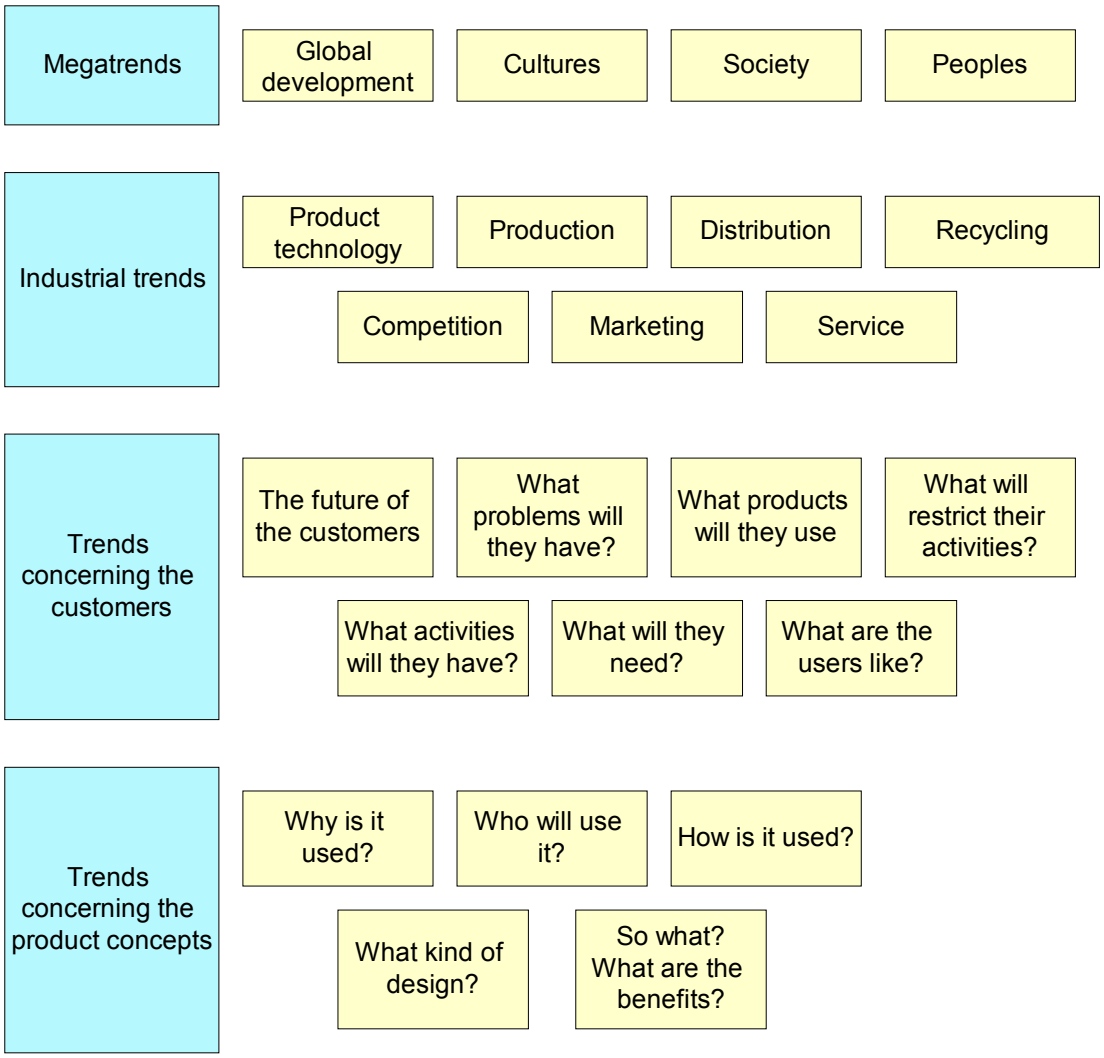

Figure 12.13. The different levels of generality of the factors of the future.

Development of Future Product Concepts

The changes of the future create threats to the present product concepts and open possibilities for totally new product concepts. The present products are modified to fulfil the new requirements of the scenarios, while the totally new concepts fulfil or create new needs and requirements. The development of future product concepts and user interface concepts is based on scenarios about the use of the product by the people in the future. It

is development of product concepts consisting of the essential characteristic and qualities of the product. The development covers the conceptions of customers, users and products and their interaction, including usage scenarios, values, functioning, advantages, and so on. The practical implementation of the future products follows later. Of course, many concepts will never be realised because we will find that the scenarios for which they are designed will never materialise or will not to be feasible. The basis of developing for the future is making choices from a set of alternatives.

Simulation of the Concepts in the Foreseeable Future Circumstances

The functioning of the new concepts is verified in the simulation phase. The aim of the simulation is to model, clarify and visualise the use of the product in the foreseeable future circumstances. The users, the products, the environment and the activities must all reflect the future. Mock-ups, role-play, cartoon and animation as well as computer modelling and virtual reality can be applied to visualise the future (Figure 12.14). The events of the future can be modelled, for example, by cause and consequences analysis and interrelation matrix.

Modern user interface development uses simulation in analytical studies and usability tests. Simulation of future situations poses challenges in simulating all the elements of the new situation, the technical and social environment, the culture, the users' attitudes, and so on. This calls for advanced techniques like drama.

Figure 12.14. The concepts are simulated in the foreseeable future circumstances.

Evaluation of the Concepts

The new concepts of products and user interfaces must be evaluated with interdisciplinary methods in order to find out the fulfilment of the future requirements and the risks to be managed. The evaluation is based on the experiences of simulation of the interface and the product concept. The evaluation of the concepts focuses on usability and verification of the scenarios. In addition, the management has to consider the business demands and risks related to uncertainties. The careful evaluation of different aspects of the future and uncertainties makes it possible to establish alternative roadmaps from the present to the future.

Decision-making

Development of concepts of future products and user interfaces does not lead directly to manufacturing and distribution of products. The development of future products is strategic and further development is always needed. The decision-making, follow up and future actions in favourable moments play an important role in the management of future products. Several aspects must be considered:

- What are the most advantageous concepts for further development?
- What concepts will wait for an opportune moment?
- How do we support favourable scenarios to come true?
- What are the most important milestones between the present and future user interface?
- What is the time scale for the development projects?
- What are risks and what risks we will take?

Product management of future concepts is based on alternative scenarios and roadmaps. The main challenge is the company's ability to follow the right roadmap. Simultaneously, the company has to look ahead to alternative scenarios that can come true.

12.7.4 The Toolbox

To facilitate designing of future user interfaces, VTT Automation developed and tested methods and procedures together with visionary companies. The development is supported by TEKES. The main objectives of the development were to:

- Help companies to create new user interface concepts, which meet the future challenges.
- Help companies to modify their existing user interfaces to succeed in changing environment and to extend their life span into the future.
- Help companies to evaluate user interfaces targeted for future environment.

VTT Automation developed a toolbox of practical methods to support the previously mentioned phases. The toolbox contains tools both for managing the development and tools for the methods – forms, checklists, etc. The tools, designed primarily to give Finnish companies the edge, are currently available in Finnish language at this WWW address: http://www.vtt.fi/aut/rm/projects/smart/ . Several other documents the approach are also available at that site.

12.8 Conclusions

There are many new possibilities for the managed development of future user interfaces. The futures studies can be used by the management of designing and design teams to map the future needs and possibilities for the user interfaces. Another potential of futures studies is that they help companies to explore the operational environment, to gain information about the users and to use scenarios of the future products. Even when most advanced methods are applied, uncertainty is an inseparable part of future and causes risks for the product development. Advanced risk analysis and risk management is essential for future oriented product development.

Management of future-oriented design processes is a demanding, serious and difficult task. The special characteristics and demands of the future and related uncertainty must be taken into account in both the management and practical processes. The future-oriented development is a strategic effort aiming to create readiness for the rapid development of future products and user interfaces in a favourable moment. The implementation of the alternative concepts will advance based on the scenario that is coming true. The limited development resources are not wasted on unessential and fallacious assumptions about the future. The main challenges of the future-oriented product development are related to production of reliable scenarios and roadmaps about the future and to evaluation of future product concepts and user interfaces in the presumable future circumstances.

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