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VICON

Virtual User Concept for Inclusive Design of Consumer Products and User Interfaces

Deliverable Report

D1.2: Survey of Design Frameworks and Tools

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Authors	Pierre Kirisci, Patrick Klein, Markus Motzelewski, Martin Hilbig, Haluk Gökmen, Petra Lundgren, Thomas Bergdahl
Quality reviewer	Thomas Fiddian
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1 Summary

The present document is part of Task 1.2 – Analysis of existing design frameworks and tools, of the Work Package 1 – Scientific and Technical Foundation. The purpose of this deliverable is to conduct a survey about existing methods, tools, and design frameworks which support the development process, particularly of user interfaces for consumer products. After an introduction to product development processes in general, several inclusive design methods are presented offering tool-based support for user interface design and validation.

Afterwards, the most widely used and successful design tools were identified and reviewed, also according to their capability of supporting inclusive design through virtual users. As a supportive action an electronic questionnaire has been created and sent to a total of 20 design companies and product manufacturers. Complementarily the industrial partners of our consortium, DORO and ARCELIK, were interviewed in order to highlight the internal product development process with the aim of finding out which design standards and tools are being used within the product development departments of the companies. Besides this, seventeen CAD software vendors were identified and interviews were conducted with them in order to find out which CAD products are capable of supporting inclusive design issues.

The survey results were visualized graphically and interpreted in the scope of identifying the most widely used methods and tools within the product development departments of the respective companies.

2 Introduction

Human factors are the biggest challenge for the design of consumer products especially when inclusive design principles are considered. The aim of inclusive design is to as far as possible make products universally accessible, with “impaired” and “non-impaired” users having similar choices of user interfaces to suit circumstance and preferences. Despite this fact, the needs of people with physical impairments are still not considered sufficiently well when designing physical user interfaces for accessing and interacting with consumer products. As a consequence currently available user interfaces and interaction devices rarely fulfil the real-time interaction and accessibility requirements of users – especially those, suffering from visual, hearing, and dexterity impairments. Thus it is not uncommon for an individual to have multiple impairments, which is particularly common among elderly people. Due to the complexities of singular and multiple age-related impairments, it is unrealistic for a mainstream manufacturer of consumer products to have a detailed understanding of these issues and to design their products in an inclusive manner. It is therefore of particular interest if there are supporting methods, tools, and frameworks available which have the capability of modelling and integrating specific needs of end users.

This deliverable addresses this challenge by analyzing several design approaches from the commercial area and from the HCI research domain. Main focus is the presentation of a survey in form of an electronic questionnaire addressing companies involved in the design and production of consumer products. Besides, an email survey with vendors of software tools for product design has been conducted in order to figure out to what extent these tools already provide a support for inclusive product design. As the final part of the deliverable, the internal product design process of the VICON industrial users DORO and ARCELIK has been described in the annex.

3 Product development

Common approaches for product design such as of VDI 2222 [VDI 1997] decompose the product development process into different phases and into a logical sequence of consecutive steps. Due to the large number of existing approaches for product design it is proposed to abstain from a detailed overview. For a more comprehensive overview the reader should refer to [Pahl et al. 2007. In relation to those approaches the product development of most companies is organized or structured in a phase-based process. Typically a product development process in a company covers all phases from first ideas to the conversion into market ready products or pilot series.

The Product development process can roughly be divided in the conceptual design (non-specific design) phase and the principal design (detailed design, specific design) phase. While the conceptual design phase deals with transition from ideas into a product, the detailed design phase covers the concretion of a concept into a prototype or concrete model. The conceptual design phase - often called “product finding” - is the creative and determining phase in a product development process. Commonly the work in this phase is supported by the usage of creative techniques and characterised by innovations. The input to be taken into account is offered by marketing activities, such as user requirement studies or feasibility studies. Further weaknesses of products in sale, or lacks in the company’s product portfolio often deliver additional input.

In contrast to this the specific design phase is usually driven by a decomposition of the envisaged product (or its representing concept) into subsystems or parts, which are designed in detail by usage of respective engineering or/and design knowledge. A concretion to a defined geometry, mock-up and assembly studies, the choice of appropriate materials, the choice of an appropriate manufacturing technologies, or make or buy decisions are only a view examples which have to be considered within this phase.

Product development has in principle a strong correlation to the process of solving problems [Mital et al. 2008]. Hence activities such as definition of the problem, a break down into partial problems or development of partial-solutions etc. play an important role in the product development phase. The correlation to problem solving processes can be found e.g. in the VDI 2221 [VDI 1993]. The German engineering association VDI produced a general design process guideline, which outlines a structured procedure analogue to a problem solving process: At first analyzing and understanding the problem in detail, then decomposing the problem into sub problems, finding solutions to these sub problems and finally combining these solutions into an overall solution, are the needed steps for this procedure. Here “finding solutions for sub problems” is not meant in finding one solution for one problem; it is rather foreseen to come up with a variety of solutions in order to pick the best option in the subsequent phase.

Nowadays the VDI 2221 is established on a European level and often copied into companies' structures. However on the other hand the approach (and the others as mentioned on top) illustrates a common weakness in many design methodology approaches: User centricity is often restricted to the product finding phase or initial process steps. Development is seen as an encapsulated process to fulfil user requirements. Even though the integration of end-users and other stakeholders into development projects has proved to reduce business risks such as the invention and acceptance of products, services and applications, the integration of the end-users along the complete product development process remains a difficult task. The Tools and methods especially for the detailed design-phase prohibit interactions between designers and end-user groups to some degree; a communication is often reduced to validation or evaluation of a given design. However, software providers are willing to address this gap in future or latest releases (e.g. CATIA V6 provides by so called "Collaborative Innovation" an online access even for prospective users [Pallai 2009]).

3.1 Established Tools supporting product development in industry

Since the initial product development steps are characterized by creativity, innovation and a need to react flexible on changing requirements, software tools supporting directly such *product finding* tasks are rarely in use.

On the one hand especially for idea generation creative techniques like brainstorming or 635 methods are well known and used in product development. Ideas are not only based on the tacit knowledge of developers. The input to these phases comes from several internal and external sources like customers (lead users), competitors, marketing (market pull) and research and production (technology push) [Pahl et al. 2005, Westkämper 2006]. On the other hand Information Technology is limited to an indirect role, such as providing structures for a quick idea exchange (e.g. mind-maps) or the preparation of sketches and initial drawings (graphic design software – e.g. ADOBE Illustrator). In reference to the latter we included off the shelf graphic software tools in order to get an up most comprehensive overview on the tools, which could be relevant in the VICON context.

In the detailed design phase most of the development tasks and sub-tasks are typically supported by so called Computer Aided Technologies (CAx), while "x" stands for a bunch of applications. The commonest application of these is Computer Aided Design (CAD). Originally focussed on the preparation of technical drawings, nowadays nearly all systems provide 3D models of parts and assembled products based on true to life parameters. High-End CAD systems are based on a so-called *parametric design*. "Parametric" means in this context, that all parameters are accessible as variables (incl. their values). This way the user is able to define formulas, rules, and similar relationships between parameters. A given design of a product (e.g. a model of a coffee-pot) can be linked to only a few explicit parameters (e.g. chamber-volume, pot-handle diameter), by setting all other parameters in a direct mathematic correlation. Hence if one of those explicit parameters is adapted the 3D model is morphing according to the predefined formulas. Those formulas and rules can not only be used for such a “design automation”, but also for checking a concrete design against given constraints (e.g. to check the pot-handle diameter against to-be values).

This leads to the field of Knowledge Based Engineering (KBE). As already pointed out by Penoyer [Penoyer 2000], knowledge based engineering appears, at first glance, to be a tautology – usually every person (and especially every engineer) involved in a product development process will define his/her engineering tasks as based on specific knowledge. Hence for our purposes, knowledge based engineering (KBE) will be defined in close conjunction with a KBE system. Within a KBE system, design knowledge is represented in a formal manner and enables the system to automate specific design tasks mostly unique to the company’s product development experience. Each KBE system provides on the one hand an interface to capture the knowledge in terms of logical rules, algorithms, or constraints, and on the other hand an output module to trigger adjacent CAD systems (or other CAx systems) or/and visualise results [Milton]. In this sense, knowledge based engineering can be seen as the process of gathering, managing, and using engineering knowledge to automate the design process by usage of a KBE system [Prasad 2005]. In this context, the meaning of “automate” even covers analysis tasks in terms of validation or quality checking. Picking up the above definition a special derivate of KBE module is expected to become a partial solution for the VICON platform. In our case rules and formulas will be derived from the user model and provided to the CAD environment.

Next to the support of the engineering/development tasks itself, there is of course also an comprehensive IT support in terms of providing an enabling infrastructure, especially in relation to data and information exchange. In order to manage product development related data adequately different forms of databases have been established within the recent years allowing a quick access to documents, CAD models (or. drawings), guidelines and similar documents. Hence they appear in various forms in order to manage different types of information: For instance product requirements and consumer needs are managed by requirements management software, CAD models and design variations are managed by product data management software (PDM), documents, rules and guidelines are managed by document management systems (DMS), FEM-data and models are managed by simulation management software and unstructured information snippets, e.g. a collection of best practices, are stored and managed by a wiki-like software or intranet portals.

Hence as an initial conclusion it can be stated, that with respect to the envisaged VICON platform and its requirement to manage user-models, environment-models etc., the needed underlying IT-tools in terms of databases and DBMS are already available.

4 Methods and tools supporting inclusive design in the product development process

Involvement of real users in all phases of the development process has so far been the most effective approach to meet the challenge of inclusive design. While designing consumer products that include interaction components (e.g. input and output components), such as dashboard panels, keyboards, buttons, switches microphones, and touch screens for operational purposes, user tests are essential for increasing usability, accessibility and decreasing human errors. Yet, such ergonomics evaluation experiments that employ many human subjects are time and money intensive.

Considering the possibility of an appropriate tool support within the early stage of the product development process, a diversity of methods and tools exist for designing software user interfaces, including multimodal user interfaces, under the consideration of specific end user needs. However, only limited efforts have been spent so far in advancing methods and tools for designing physical interaction components of consumer products in an inclusive manner [Kirisci, Thoben 2009].

Accordingly this chapter surveys existing methods and tools which are capable of supporting the early stages of product development under consideration of the needs of users regarding accessibility to the envisaged product.

The focus of this chapter is rather on the identification of design methods and tools emerging from the academic domain than on methods and tools which are commercially available and well-established in the product development departments of companies. The reason is for this approach is pragmatic - design support tools that particularly focus upon the virtual design of interaction components of consumer products under consideration of universal design principles are still uncommon in industry.

The next section will provide an overview of methods and tools which are applicable for designing:

- hardware components
- interaction concepts
- interactive systems
- user interfaces

The first category particularly focuses upon the design of physical user interfaces, while the second and third category have a more universal focus. Most important is that only methods and tools were considered that incorporate mechanisms to ensure inclusive design support. Although the design methods are described rather than software tools, one should be aware that software tools exist for each method which finally make the methods applicable for the designer.

4.1 Methods and Tools for Supporting the Design of Hardware Components

One of the very few approaches dealing with the design of mobile hardware components especially for wearable computing systems was developed in 2003 by Bürgy [Bürgy, Garett 2002]. There a "mobile and wearable computer aided engineering system" (m/w CAE System) is proposed. By defining a constraint model Bürgy describes scenarios where support for a primary task is needed. Based on this model, existing comparable solutions are identified or new adapted systems are drafted. The description of an exemplary scenario is realized by using elements of four sub models: (a) the user model, (b) device model, (c) environment model, and (d) application model. The authors also present a software tool called ICE-Tool (Interaction Constraints Evaluation Tool) to set up such constraint models and in order to look up implementations for similar scenarios in a database. The intention is to make design knowledge from past applications available even to domain experts who are not systems developers. Because of a strong abstraction, a simple communication of scenario elements is very limited. The sub models are intentionally kept very simple, since the main focus of this approach is the identification of similar work situations. Also, most of the attributes of the sub models are defined by binary decisions, making detailed design decisions in combination with the simple sub models. A shortcoming is the small number of different interaction devices to choose from. For instance, the device model cannot distinguish a device needing tactile interaction from one which does not.

Another approach for a design support regarding mobile hardware components in the field of wearable computing was published by Klug in 2008 [Klug 2008]. He states that, although the technical background for wearable systems is very advanced, there are crucial shortcomings in the support of the early stages of the design process. Due to the nature of such systems, an intense integration of the actual user is mandatory during the design process, but common user-centred design approaches do not take account of the specific properties of wearable computing. The solution he proposes consists of three parts. The first part is focused on the documentation and communication of specific use cases. Shortcomings in these fields lead to misunderstandings and false assumptions which will produce many subsequent errors during the design process. This challenge is met by the definition of models allowing a correct representation of wearable computing scenarios to enable a systematic documentation of use cases. The goal is to make the representation comprehensible for the whole design team and thus enabling the interdisciplinary communication between the members from different backgrounds. The author points this characteristic out to be of outstanding importance on the way to the design of an optimal wearable device for a given scenario. Another part of solution deals with the provision of models and tools supporting the selection and configuration of suitable devices. The last part finally, considers the mutual influence of different interaction devices on each other and the work wear of the user, thus taking the aspect of multitasking into consideration. Klug presents an integrated user-centred design process, supported by three models, a work situation model, a user model, and a computer system model. Based on these, a scenario can be simulated, identifying the compatibility of an interaction device with it. Due to the intense and specific design to a certain type of use case, the approach lacks of easy adaption to scenarios with completely different specification. Klug's work aims to describe use cases in a very fine granularity which makes it suitable for well-defined, recurring tasks in a fixed, well-known environment. Use cases with changing environments and slightly unpredictable tasks cannot be described on such a high level of detail without limiting the flexibility, necessary to cope with dynamic change.

Alternative hardware components for interaction between users and computing systems can be represented by “tangible user interfaces” (TUI). The idea behind this paradigm is the transfer of graphical software icons to complimentary hardware widgets. Compared to the typical interaction components, which enable user access to consumer products such as switches, dials, buttons, etc., tangible user interfaces have very similar characteristics. Ishii and Ullmer were the HCI researchers who made the paradigm of tangible user interfaces popular, thus were responsible for some substantial advances in this area [Ishii, Ullmer 1997]. In this respect, a diversity of software tools and frameworks emerged during the last ten to fifteen years. One design methodology for tangible user interfaces called “Symmetries-Of-Use” was introduced in 2004 by Champoux and Subramanian [Champoux, Subramanian 2004]. The aim was to realise a seamless coexistence between form and context – most likely this principle was adopted from Christopher Alexander, who was the first to define relations between a context, a problem and a solution, which he called “design patterns” [Alexander et al. 1977]. As illustrated in Figure 1 Champoux’s methodology consists of eight questions, which represent a collection of clear and interrelated decisions during the development process of tangible user interfaces.

Limit Definition	Component Orientation	Component Adjustment
1. What are user experiences 2. What are user tasks 3. How is the object represented and controlled 4. What are the conventions	5. Type of interaction within the subtasks 6. Does the subtask require a specific interaction	7. Relations between objects and tasks 8. Order of tasks upon usage of the object

Figure 1: Die Symmetries-of-Use method consisting of eight questions

Methods and tools focusing upon interaction concepts instead of the hardware components themselves can also be worth reviewing in this context. In 1996 Chang and Ishii introduced a method for the design of multi-sensorial mappings [Chang, Ishii 2006]. The methodology considers the inclusion of sensorial aspects through the design of physical and digital interactions. Based upon this, the "sensorial activity theory" was introduced. According to them, the design process of sensorial user interfaces should be based upon three aspects: (1) Understanding of the senses; (2) Understanding of the physical semantics of an object; (3) understanding of the habits of the user. A similar design method in this area was proposed by Belotti who proposed a design approach for creating sensing systems [Belotti et al. 2002].

4.2 Methods and Tools for the Design of Interactive Systems

A technology-driven and user-centred method in order to realise innovative and interactive technology, such as interaction components for consumer products, is the "Transfer Scenarios Method". The method is based upon the inclusion cautiously chosen groups of individuals which perform similar tasks called marginal practices. The method includes the following course of action: (1) Learning the technology; (2) Adaptation of the technology to the marginal practices; (3) Investigation of user needs and interactions; (4) Analysis and transfer of data to the conceptual design; (5) Detailed design and technology development. Due to the strong user focus of this method, the context has to be known and be integrated in the design process, which is ensured through (3).

Regarding the incorporation of context in the design process Beyer and Holtzblatt have developed the "contextual design method". According to this method, data collected from the user are the basis for the development of an interactive system [Beyer und Holtzblatt 1998]. The contextual design method embraces an approach as illustrated in Figure 2. Throughout the design of a system, only those techniques are considered which are necessary in the design process. Usually established HCI techniques are employed here.

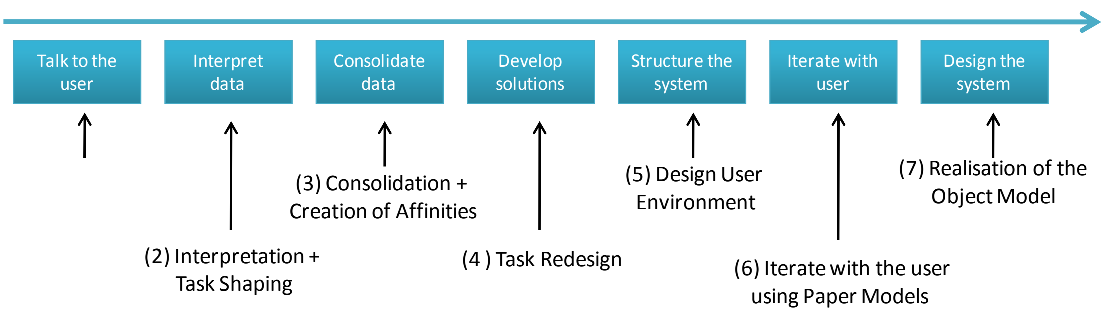


Figure 2: Process of the conceptual design method

Another method which is appropriate for developing user interfaces for the largest possible group of users was proposed by Savadis and Stefanidis [Savadis et al. 2001]. The method is called the “Unified Design Method” and is based upon the approach of a very precise analysis of the context of use and its systematical break down in sub-problems.

Also Furtado et. al. Proposed a method for the universal design of user interfaces [Furtado et al. 2001]. The base principle of this method consists of the building of layers: (1) conceptual layer: definition of an ontology of concepts, relations and attributes; (2) logical layer: Specification of multiple models upon the existing ontologies developed in (1); (3) physical layer: Development of derivations of multiple user interfaces from the previously specified models.

The next section of this chapter picks up the incorporation of models in the design process, and focuses upon design methods and tools that are based upon the usage of conceptual models.

4.3 Model-based design methods

Design methods which are based upon the usage of models when creating user interfaces is an established approach in the area of software development. These design methods are referred to as model-based design methods. Until today it is still not common practice to use model-based methods for the conceptualization and specification of consumer products. Due to the success of model-based methods and tools in the area of graphical software development, these methods were advanced and adopted for designing context-oriented user interfaces in intelligent environments. Context-oriented user interfaces are user interfaces that are able to adapt to the context of the user and his environment. The underlying development approach consists of six steps called „Dynamic Model-Based User Interface Development Process“ (Dynamo-Aid) [Clerckx et al. 2005] (1) Specification of a context-oriented task model; (2) specification of a context model; (3) Development of context-specific dialogue models; (4) Development of context-oriented dialogue model; (5) Development of the presentation model; (6) Development of the context-oriented user interface model. These six steps lead to a model specification which can be fed into a runtime environment. Figure 3 illustrates the prototype of the emerged user interface which is then again evaluated through six modeling steps. This process is continued for so long until the user interface is implemented on to the target platform.

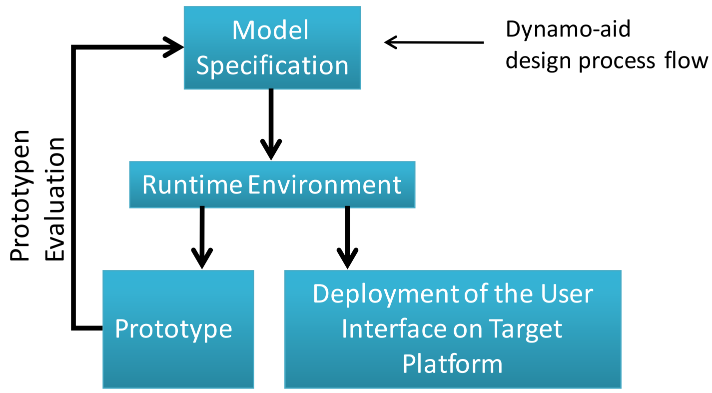


Figure 3: The Dynoma-Aid Design Process

Luyten et al, proposed a method for the development of distributed user interfaces (DUI) which is called “MoDIE” (Mobile Distributed User Interface Engineering) [Luyten et al. 2005]. The idea of the method is to relate tasks to a set of interaction resources that are focused upon the performance of the task. Interaction resources are input or output devices – as such interaction components of consumer products can be considered as interaction resources. The designer is entitled to define a number of decision rules in order to come up with alternative tasks related to the individual context. In supplement to the distribution of user interfaces, Demeure et al, proposed a reference model for the classification of different types of DUIs [Demeure et al. 2005]. The reference model is composed of digital and physical components. Related to the adaptation of user interfaces it appears that concepts come into effect that can be traced back to Calvary et al, who have introduced a design process for so called plastic user interfaces [Calvary et al. 2001]. Plastic user interfaces are defined as user interfaces which can adapt their appearance according to the specific context. Contexts are divided into two categories: (1) Hardware and software platform and (2) physical environment. The design methodology proposed by Calvary et al, is based upon the development and improvement of models for HCI user interfaces which adapt themselves to variations of context.

Florins and Vanderdonckt introduced a design method for the conceptualization of user interfaces for multiplatform systems [Florins und Vanderdonckt 2004]. The method is based upon a technique called “design by graceful degradation”. The technique involves defining transformation rules for the decomposition of user interfaces, which strongly reminds of the concept of hierarchical decomposition defined by Savadis and Stefanidis [Savadis et al. 2001]. It must however be noted that the design approach of Vanderdonckt focuses particularly upon the adaptation of optical output components (e.g. visual displays) regarding different platforms.

5 Questionnaire

5.1 Objectives

The objective of the questionnaire was to the systems used within the product development departments of companies engaged in the design of consumer products. The aim was also to gather information about their design process, and design standards especially in regard of inclusive design. The information was collected anonymously and provided by employees involved in the design of consumer products from the earliest stages on. A total of 20 companies have been contacted.

5.2 Questionnaire results

The questionnaire was developed with Adobe life cycle designer, while the results are based upon xml for a more easy statistical evaluation. A total of 20 companies from the area of consumer product development were consulted by email and telephone. Unfortunately only nine companies provided a comprehensive feedback so far. Some few companies stated, that for company policy reasons they were not willing to provide feedback about their product development process.

In spite of the limited feedback the results of the questionnaire can nevertheless be considered representative for our purposes. Figure 5 shows a screenshot of the questionnaire while Figure 5 shows a screenshot of the results menu of the questionnaire. It should be noted that in order to make the feedback process as simple and as comfortable as possible, the questionnaire offered the feature of providing feedback per 1-click.

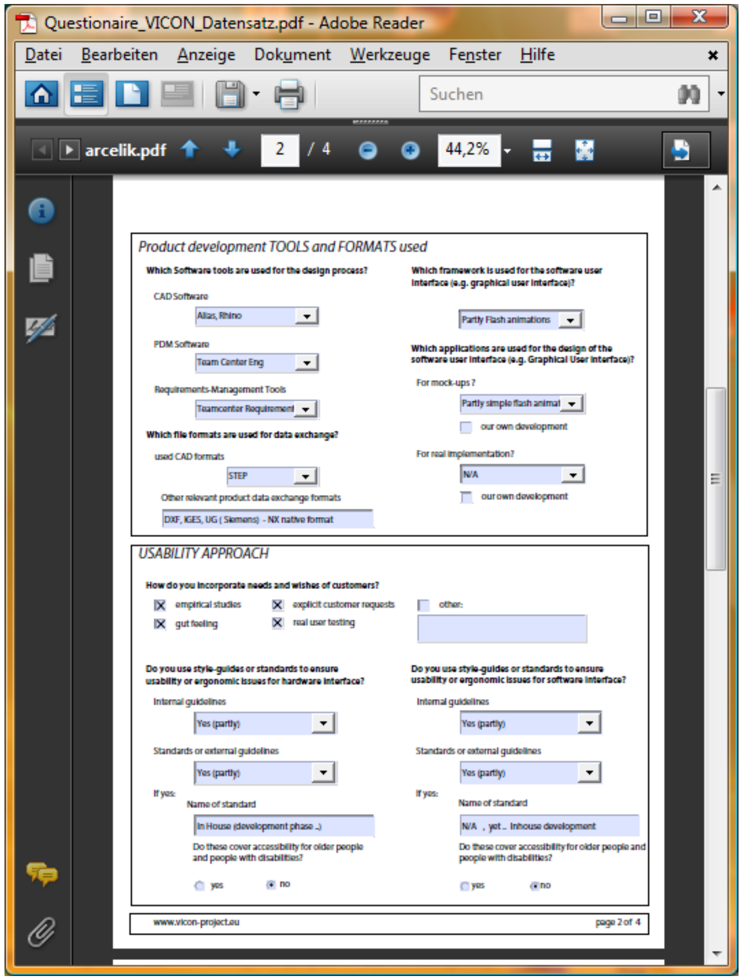
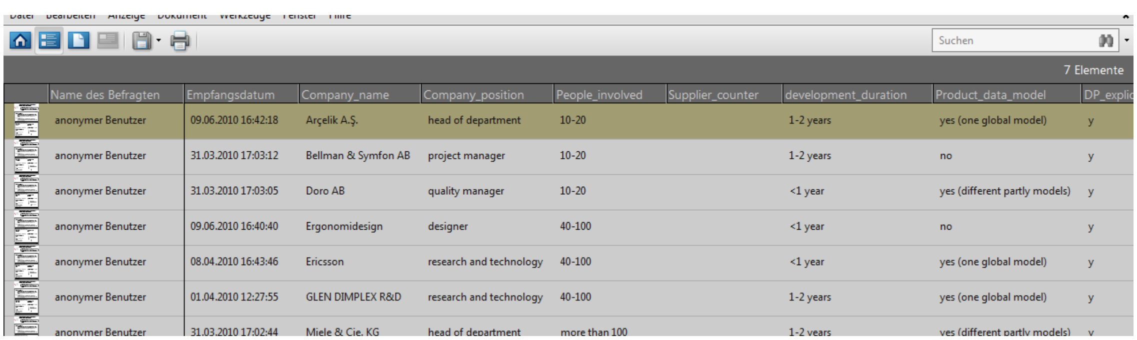


Figure 4: Screenshot of the questionnaire



Name des Befragten	Empfangsdatum	Company_name	Company_position	People_involved	Supplier_counter	development_duration	Product_data_model	DP_explic
anonymer Benutzer	09.06.2010 16:42:18	Arçelik A.Ş.	head of department	10-20		1-2 years	yes (one global model)	y
anonymer Benutzer	31.03.2010 17:03:12	Bellman & Symfon AB	project manager	10-20		1-2 years	no	y
anonymer Benutzer	31.03.2010 17:03:05	Doro AB	quality manager	10-20		<1 year	yes (different partly models)	y
anonymer Benutzer	09.06.2010 16:40:40	Ergonomidesign	designer	40-100		<1 year	no	y
anonymer Benutzer	08.04.2010 16:43:46	Ericsson	research and technology	40-100		<1 year	yes (one global model)	y
anonymer Benutzer	01.04.2010 12:27:55	GLEN DIMPLEX R&D	research and technology	40-100		1-2 years	yes (one global model)	y
anonymer Benutzer	31.03.2010 17:02:44	Miele & Cie. KG	head of department	more than 100		1-2 years	yes (different partly models)	y

Figure 5: Screenshot of the results menu within the questionnaire

To get an intuitive understanding and easy overview about the results the questionnaire was structured into different logical sections:

1. Information about company size, product development process and role of the respective representatives within their company
2. Information on used Tools and formats
3. Statements on the Usability approach, style-guides and customer incorporation
4. Statements on Inclusive design
5. Rapid-Prototyping and Virtual-Prototyping
6. Statements in relation to a concrete future scenario
7. Remarks, comments and suggestions

The Results and conclusions as given below try to pick up this logical sequence in order to leave a linkage to the original questionnaire.

With respect to the interviewees it can be stated that the questionnaire was always forwarded to the “valuable” persons. All persons are related to, most of them are directly involved in and some of them are even leading the product development group of their company.

Nearly all companies have less than 100 people involved in their product development process. This fits to experiences from other research projects. Despite special branches such as aircraft, or automotive industry the development teams (especially the SMEs) are of moderate size.

All involved companies have made their development process explicit. They all have a process diagram and in addition more than 60% rely on explicit procedure documents or development schedules. This means, on the one hand an important requirement of VICON has to be to come up with a solution, which is scalable and adaptable to exiting product development structures. On the other hand the envisaged solution can rely on such explicitness e.g. in terms of addressing different phases with different tools.

Next to the process itself about 75% of the companies come up with an explicit product data model. This is “good news” with respect to our idea of suggesting “components” in compliance to our user model in the early phase of the product development process. The conceptual breakdown into sub-systems or components is an important pre-condition for our approach.

Nearly all companies rely on CAD software. Hence, the VICON idea of providing a linkage to CAD in the second phase of VUM is not insignificant. Figure 6 shows a distribution in relation to the different CAD applications. However, this distribution has to be handled with care (since the total amount of data is not huge), but it may serve as an indicator for a tendency. The questionnaire included also a request on CAD and data-exchange formats. The purpose was on the one hand to validate that it is possible to transfer a digital representation of the product into a kind of validation and evaluation environment (similar to DMU analysis tools) and on the other to find out later one which existing platforms (e.g. human modellers etc.) may suite as a basis for this validation and evaluation environment.

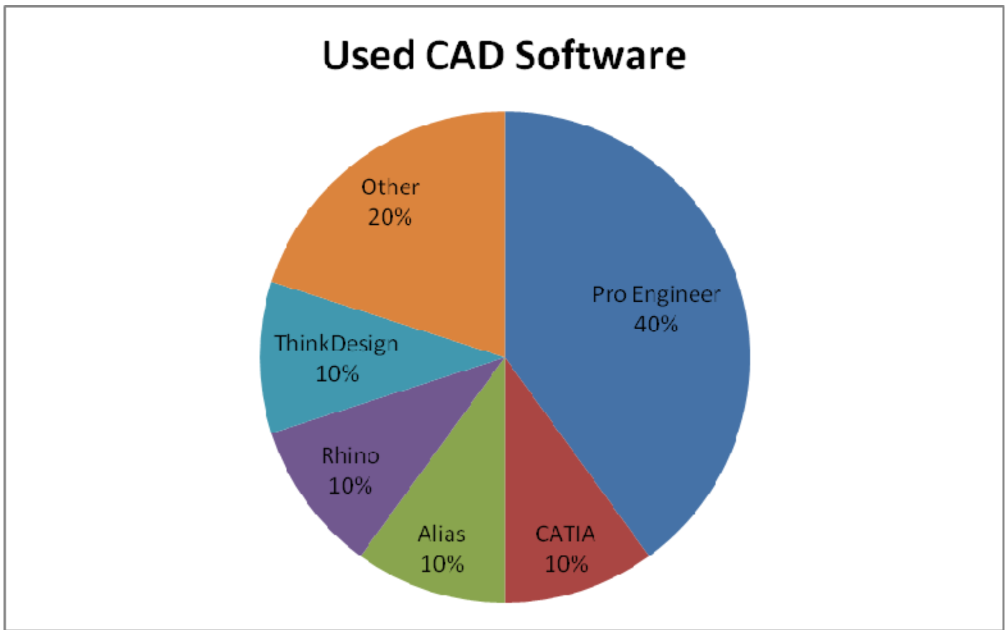


Figure 6: Most Used Design Tools (Numbers indicate percentage among questionnaire participants)

In contrast to the diversity of used CAD software the tools used for software (SW) or graphical user interface (GUI) development are not named explicitly. But for GUI mock-up Adobe SW, especially Flash, is in use by 50% of the interviewed companies.

Regarding the used techniques and methods for integrating user needs in the product development process it can be seen in Figure 7 that most companies take benefit upon real user testing and customer requests (89 % of the participants). It was also confirmed that still a rather large number of participants do not use a specific technique, but rely on their “gut feeling” (67%), while 56% consider using empirical studies.

An evaluation of the Virtual user model / the VICON approach (later on) should provide further details on the question, if the VICON solution has to become an additional source to incorporate needs and wishes of customer or a replacement.

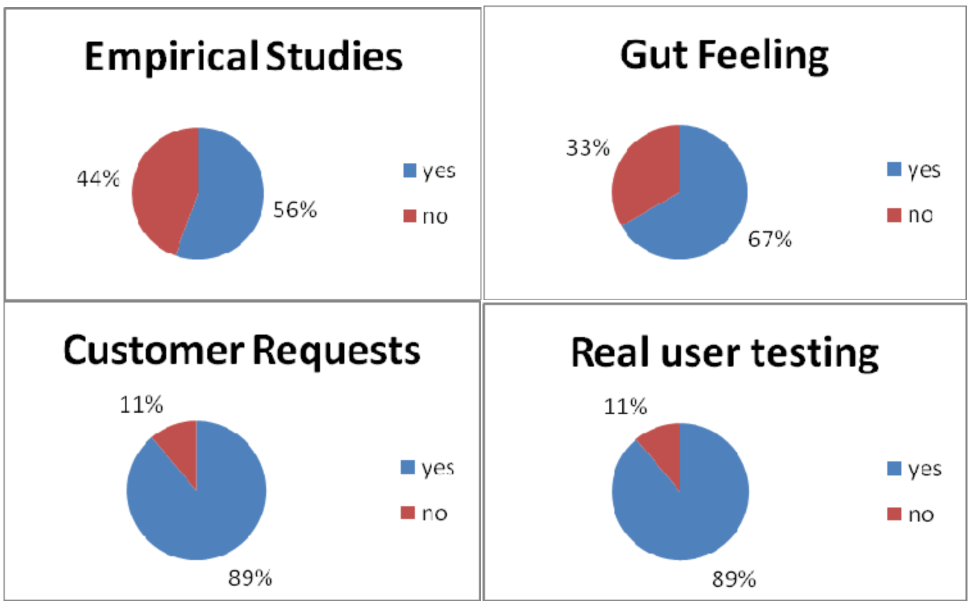


Figure 7: Most used techniques during the products development process for integrating user needs.

With respect to style-guides the survey turned out, that companies rely on style-guides or not: If they use style-guides for software they use guides for hardware either, if they use internal ones they use external ones either. At least according to our data the use of style-guides seems to be a matter of awareness and experiences.

In total only two external standards have been explicitly named: EN-614-2, EN50134.

The use of SW-tools or plug-ins to ensure usability or ergonomic issues is not common or turned out not to be helpful. Herewith appears a challenge with respect to the exploitation of VICON results. While at least some of the companies use Questionnaires models or mock ups, there seems to be not yet an established market for SW plug-ins or tools to ensure usability or ergonomic issues. This fits to the answers given about inclusive design: Although more than 70% percent of the companies are stating explicitly to address inclusive design, none of the companies uses a specific software to validate inclusive design, but a validation by respective end-user groups is widely used.

Virtual prototyping is in use by nearly all companies and (Surprisingly) Virtual prototyping is in use by more than 50% of the companies for usability and ergonomic issues of impaired or elderly user groups. CAD systems or/and respective enhancements are in use in this context.

Rapid-Prototyping is in use by nearly all companies and by more than 60% of the companies even for or usability and ergonomic issues of impaired or elderly user groups.

So, the involved companies are not only aware of Virtual prototyping and Rapid prototyping technologies but are also aware of the possibility to make use of these technologies in the context of usability of disabled people.

With respect to the given scenario the way to react on differs between the companies, however all companies think a systematic support for adapting user interfaces would be helpful. Hence there is a need for solution which addresses such scenarios.

6 Email Survey

6.1 Objectives

The purpose of the email survey was to gather information on state-of-the-art design software. In this task seventeen CAD software vendors were contacted, and an inclusive design scenario was presented to them. The companies were asked to suggest the best-suited tool which is capable of coping with the issue of inclusively designing products.

6.2 Design Tools Overview

The following section shows a list of software design tools which are described with respect to their capability of supporting inclusive design.

- **Alibre Inc. - Alibre Design**

  Alibre is a parametric 3D CAD Solution focused on machine design. It has no known virtual human model functionality, neither included nor per 3rd party plug-in.

- **Autodesk – Alias, Inventor, 3DSMAX**

  Autodesk Alias line offers a complete set of sketching, modelling and visualisation tools. It can be integrated with Inventor, the Autodesk solution for machine design, for data transfer into digital prototypes. 3DS Max is a modelling and rendering solution primarily for 3D visualisation. Neither offers a virtual human model for usability analysis.

- **Dassault Systèmes – SolidWorks, CATIA**

  CATIA have been developed to meet the PLM needs of larger companies, particulary those in the aerospace, automotive, shipbuilding and industrial plant industries. As a CAD tool, CATIA's focus and goal has been on 3D modelling and digital mock-ups as replacements for engineering drawings and prototypes. CATIA offers with Human Builder a virtual human module for ergonomic design and analysis. Human Builder consists of a number of advanced tools for creating, manipulating and analyzing how manikins can interact with a product. The manikins can then be used to assess the suitability of a product for form, fit and function. The manikins can be intuitively created and manipulated in conjunction with the digital mock-up to check features such as reach and vision.

  SolidWorks is a CAD solution primarily for mechanical engineering and does not provide a human model solution.

ICEM has been recently acquired by DS and is now part of the CATIA PLM Suite. It is a Class A-surface modelling, surface analysis and design visualisation software, but does not provide further human model functionality.

- **IronCAD LLC. – IronCAD**

  IronCAD is a versatile 3D hybrid modeller—in other words, a program that can use parametric as well as explicit methodologies. IronCAD 9 can be either history-based—using sketches and constraints to control how things are constructed in a particular order—or non-history-based—building geometry without regard to the construction order. That choice allows users to model the forms they want virtually without regard for how the software wants to do things. Modelling can be quite freeform, but controlled when appropriate, achieving this due to its design as a triple-kernel software, with ACIS, Granite One and Parasolid kernels doing the job where appropriate. As well as IronCAD performs as a tool for industrial design, it still does not provide any ergonomic analysis tools or plug-ins or any virtual human model functionality.

- **ISD Software und Systeme GmbH – HiCAD**

  HiCAD is a 2D/3D CAD Solution based on the ESM Kernel. Its applications cover mechanical product design and development, machine building and sheet metal applications, industrial and commercial steel structural constructions, piping and plant construction and metal construction (facades). It does not facilitate a human model.

- **Kubotek – KeyCreator**

  Kubotek KeyCreator, formerly known as CADKEY, is a 3D CAD/CAM application software, mainly used in manufacturing and tools design. KeyCreator allows editing import solid models as it is created natively. KeyCreator support many standard and most common 3D and 2D model file formats in both import and export direction. It does not facilitate a human model.

- **McNeel - Rhino3d**

  Rhino 3D is a stand-alone, commercial NURBS-based 3-D modelling tool, developed by Robert McNeel & Associates. The software is commonly used for industrial design, architecture, marine design, jewellery design, automotive design, CAD / CAM, rapid prototyping, reverse engineering as well as the multimedia and graphic design industries. It does not facilitate a human model.

- **Punch! / POSH GmbH – SharkFX**

  Punch! Shark FX is focused on conceptual and preliminary design for those requiring precision content for 2D/3D digital models. Shark is a full featured package uniquely positioned to provide solutions that address versatile modelling practices, photorealistic rendering, animation, and precision drafting capabilities all within one seamlessly integrated package. It includes translators to enterprise CAD system such as CATIA™ and Pro-E™ and 2D dimensional constraint management methods for rapid design iterations. It does not feature a human model system.

- **PTC – Pro Engineer**

  Pro/ENGINEER is a parametric, integrated 3D CAD/CAM/CAE solution created by Parametric Technology Corporation (PTC). Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These capabilities, include solid modelling, surfacing, rendering, data Interoperability, routed systems design, simulation, tolerance analysis, and NC and tooling design. Pro/Engineer can be extended with Manikin and Manikin Analysis, two modules for ergonomic design and human-factor analysis, allowing creation and evaluation of reach zones, field-of-view and other aspects of human-machine-interaction.

- **Siemens PLM Software - Siemens NX**

  Siemens NX is the current flagship product from Siemens PLM. It offers an integrated interactive CAD/CAM/CAE system. Siemens NX features NX Human Modelling. Based on Tecnomatix Jack, it allows for accurate human models, use of anthropometric databases, and features editing and positioning of human models within the product development environment and creation and evaluation of reach zones to determine clearance and interference.

- **Tebis Technische Informationssysteme AG – Tebis CAD**

  Tebis provides integrated CAD/CAM solutions focused on die, mold and pattern manufacturers. It is not intended to be used with a human model, and provides no such functionality.

- **Think3 – thinkdesign**

  Thinkdesign is a streamlined suite of CAD/CAM/PLM solutions. It covers all ranges of product design, from imagery import and surface modelling to global shape modelling, solid modelling and rendering simulations. It does not provide a human model though.

- **VariCAD - VariCAD**

  VariCAD is a 3D/2D CAD system for mechanical engineering. In addition to standard tools for 3D modelling and 2D drafting, the CAD system provides support for parameters and geometric constraints, tools for shells, pipelines, sheet metal unbending and crash tests, assembly support, libraries of standard mechanical parts (ANSI, DIN) and symbols, mechanical part calculations and tools for working with bills of materials (BOM) and title blocks. No human model system is available.

- **Vero Software Plc - VISI**

  VISI is a leading PC based CAD / CAM solution for the Mould & Die industries. It offers a combination of applications, fully integrated wireframe, surface and solid modelling, comprehensive 2D, 3D and 5 axis machining strategies with dedicated high speed routines. Industry specific applications for plastic injection tool design including material flow analysis and progressive die design with step-by-step unfolding provide the toolmaker with unsurpassed levels of productivity. The software does not facilitate a human model system.

6.3 Survey results

The survey showed that all of the above viewed software products support similar technical functionalities. The difference lies (1) in the usability and (2) in the supported plug-in. It can be pointed out that the integration of functionalities for designing and testing with virtual users is managed via "Virtual User Plug-ins". Thus, different tools support different virtual user plug-ins. Interesting is that a link to Deliverable 1.3 can be established here, as D1.3 provided an overview of tools, particularly software plug-ins that offer the integration of virtual users in the design process. As a consequence there exists a link between the CAD tools analysed in this deliverable and some of the plug-ins incorporated in D1.3. Figure 8 highlights this relationship. Regarding the virtual user plug-ins, we focused particularly upon two tools in more detail:

(1) RAMSIS by Human Solutions

(2) SAMMIE CAD by University of Loughborough

Regarding those two tools, the VICON consortium is currently in face-to-face negotiations with Human Solutions in Germany and with University of Loughborough in UK in order to explore the possibilities of cooperation regarding usage of their human models and its extension.

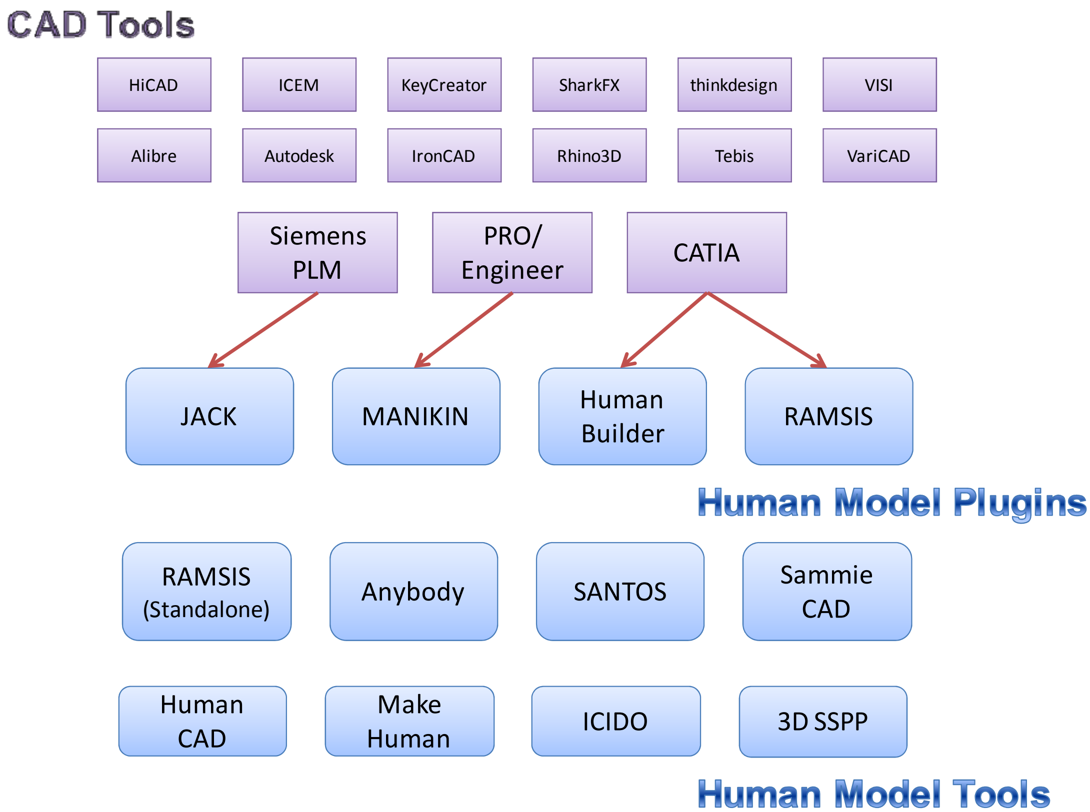


Figure 8: Mapping between CAD Software tools and plug-ins identified in the scope of Deliverable D1.3

7 Conclusions

The survey on HCI methods and tools in chapter 4 of this deliverable provided a comprehensive overview of existing methods and tools for supporting the design process of products, technology, and user interfaces. It should be noted that even though the core of the discussion was about methods, many of the addressed design methods are supported through software tools or frameworks. It became clear that the majority of the identified design methods are unknown in industry. One of the reasons for this phenomenon might be grounded in the fact that none of the design tools are seamlessly integrable to widely spread CAD and CAx tools as regarded in chapter 5. However, the VICON consortium considers some of the approaches pursued in model-based design methods as highly promising. Thus, some of the theoretical approaches will be put to practice. Deliverable 2.4 will point out this aspect more clearly.

In spite of the fact that the data basis in the survey in chapter 5 is apparently poor, it still is possible to draw clear conclusions. First it can be said that different CAD/CAx tools are applied in industry. Pro Engineer is definitely the design tool which is most widely used. Within the VICON framework it is foreseen to use Catia software. Catia has similar core functionalities as Pro Engineer, but has the advantage of the availability of certain modules (e.g. KBE modules) that are necessary when integrating the VICON framework. These KBE modules are also the most advanced ones currently available on the market. In all CAD systems either rudimentary or even no functionalities exist for the ergonomic analysis and design of products. However, plug-ins or additional modules are offered in form of software which includes 3D human models for the ergonomic analysis of virtual product constructions. A more detailed insight about these kind of software tools is provided in deliverable 1.3. Respective tools are usually not yet used for the design of consumer products such as the ones considered in VICON. For the design of more complex products such as automobiles, aircrafts and ships, the usage of these kinds of software tools is more common.

Regarding external design standards, it became clear from the results of the questionnaire that only very few standards are used within the consulted companies. Particularly standards such as the DIN EN 614-2 are mentioned, the focus of which is more on general design recommendations as on inclusive design. The industrial partners in VICON – DORO and ARCELIK – both align their product development processes on well-established guidelines such as VDI 2221.

For now it can be stated that for the VICON framework, a standardized user interface between the environment that provides the 3D human model and the environment where the product is virtually constructed. Accordingly, two possibilities arise: (1) The application can be connected with the CAD software via plug-ins or APIs (e.g. Tecnomax in Pro Engineer); (2) Delivery of the product model data via an established data exchange format (e.g. AP214, IGES or VRML). For the realization of (2), the software tools have to provide a specific import functionality for the ergonomic analysis. The yields the limitation that software applications such as MakeHuman, which provide these kind of interfaces only rudimentarily, are not usable in the context of VICON.

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APPENDIX A Internal design processes – Confidential

This part of the deliverable provides an overview of the internal design process of the VICON industrial partners DORO and ARCELIK. Due to company-policy reasons, this information is considered confidential and is not publicly available.

9 ARCELIK's Design Process Activities

The design process at Arcelik as seen in Figure 9 defines the activities for planning, tracking and controlling of Arcelik's new product development projects.

The Capability Maturity Model Level 3 (CMMI L3) based development process and Brand guidelines are used in the design process. In addition style-guides or brand-standards are used, Arcelik's best-practices – knowledge base are included to process schedule and also validation and quality assurance is needed by respective groups and end users.

ProEngineer is used as a design tool. In addition to that Compiler, Debugger and Code editors are used in software development. CVS and Starteam Borland are used for configuration management. Starteam Caliber RM is used for the requirements management. User Interface design is being done by platform based UI tools and self-development.

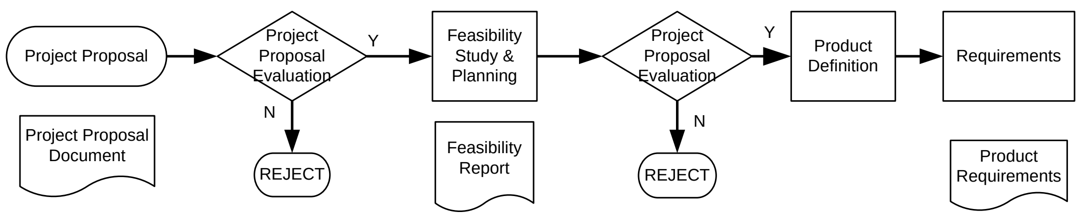


Figure 9: Project Proposal Flow

The basic process activities are summarized below in the following sub-sections.

9.1 Proposal Phase

Arcelik Product Management Department and/or other departments prepare Project Proposal Document for their new product requests.

The Product Management Department is responsible to organize PPR (Project Proposal Review) meetings to review the Project Proposals. During the PPR meetings, the Project Proposals are evaluated along with market, cost, timeline and forecast sections of the Project Proposals considering company objectives and strategies and an ACCEPT/REJECT decision for each proposal is given which is recorded in the related folders on the Arcelik Intranet.

PMO Manager assigns a Project Manager to each accepted Project Proposal to initiate project planning activities.

9.2 Establishing the Core Team

The PM (Project Manager) coordinates with the Department Managers to select the individuals with skills and experience appropriate to the individual roles as well as to the project requirements to establish the core team of the project.

9.3 Feasibility Study

9.3.1 Project Scope Definition

The core team defines the project scope by working with the Product Management Department and Benchmarking Office. The PM is responsible to organize the working sessions.

During the project scope study, the core team defines high level requirements and architecture of the product. The following issues are investigated:

- Functionality
- Out of scope features
- Interfaces
- Similarities and/or differences with other products; benchmarking

The core team documents its findings in the form of Feasibility Report.

9.3.2 Concept Analysis

Based on the Project Proposal and information gathered during product scope studies the core team defines the priorities for the items on Concept Evaluation Form which is part of feasibility report and used to evaluate product concept alternatives.

The core team, based on the priorities, selects among the product concept alternatives and records the rationale for decision.

9.3.3 Preliminary Project Management Plan

The PM, with feedback from the core team, prepares a high level project plan including high level work packages, major milestones, effort and budget estimates.

The PM records the high level plan into the Feasibility Report.

9.3.4 ROI Analysis

Based on the estimated schedule and the estimated amount of work a preliminary ROI (Return On Investment) analysis is done. After completing the ROI analysis which is documented in Feasibility report, PM ensures that the report is ready for the review.

The PMO organizes a Concept Review Meeting (CRM). Concept Review Meeting results can be acceptance, rework or reject. The core team updates the Feasibility Report to reflect the decisions and suggestions made during the Concept Review Meeting.

9.4 Project Planning

The PM performs the following project planning activities in cooperation with the core team members and prepares the Project Management Plan (PMP).

The PM also utilizes organizational assets entities during planning activities such as

- Project Management Plan(s) of similar projects (size, application domain, etc)
- Project closure reports of similar projects
- Measurement Repository

The PM also plans the planning tasks defined in this procedure and assigns appropriate personnel to these tasks. The PM is the responsible body to monitor the planning activities and take corrective action when needed.

The PM coordinates with the Department Managers to identify the appropriate staff (those with the required skills) to allocate to the project.

Based on the Feasibility Report, the PM prepares WBS for the project.

The WBS covers the tasks for

- Planning and monitoring activities
- Development activities (e.g. software, hardware)
- Supporting activities (e.g. training, configuration management, risk management, quality assurance, maintenance)
- Integration and management of non-developmental activities (e.g. integrating reusable components)
- Acquisition and reuse

The PM establishes project schedule in the form of a Gantt chart considering the following:

- Time phasing of activities

- Dependencies between the activities
- Milestones identified
- Duration of activities
- Frequency of the progress/milestone meetings
- Assumptions and constraints related to the scheduling
- Return Of Investment Analysis

The PM establishes the project budget based on resource cost estimates and estimates for other expenses related to the project (infrastructure, training, travel etc.) and documents the project budget.

9.5 Software Development Management

The PM and The Department Manager establish a Project Management Team involving at least a Software Leader (SL), Software Quality Assurance Representative (SQAR) and Software Configuration Manager (SCM). The PM and Department Manager select individuals for the Project Management Team with skills and experience appropriate to the individual roles.

The PM asks the Software Leader (SL) to plan for the software development activities based on the Preliminary Project Management Plan. The SL needs information from Requirement Development Process to have the details of the Project to complete the plan for software development.

The SL establishes the software development process using the standard procedures and other defined assets (e.g. guidelines, templates). Based on the product requirements, Arcelik Process Tailoring Guidelines, and Software Life Cycle Definitions (e.g. waterfall, iterative, agile), the SL decides on the project life cycle and the activities that will be executed within the context of software development (e.g. software development process). The WBS reflects the decisions regarding to the software development process:

- Requirements development
- Requirements management
- Design, and coding
- Product integration
- Software testing
- Software configuration management
- Software quality assurance

Depending on the project's specific requirements, the SL might need to adapt a process/method/tool that is not defined in the Arcelik Process Asset Library (PAL). In this case, the SL documents the rationale for each deviation from the standard processes.

The SQAR reviews the project's defined process and ensures that it is aligned with Arcelik Process Tailoring Guidelines and process management infrastructure. The review of the project's defined process is performed in accordance to the Software Quality Assurance Process. The SL resolves the issues identified in the review.

If there are deviations from the standard processes, the PMO approves the project's defined process.

The SL documents the project's defined process by extending and organizing the WBS in the Project Planning Tool. The SL establishes estimates for software work products using Arcelik Estimation Guidelines. The SL may form an estimation team in case of need.

The Hardware Development, Mechanical Development and Industrial Design management and planning is similar to software development management process defined above.

The PM, together with the team leaders e.g. SL reviews all project plans (Project Management Plan, Software Development Plan, Hardware Development Plan, Mechanical Development Plan, Industrial Design Plan, Test Plan, Procurement Plan, Production Plan, Contractor Plan, Configuration Management Plan and Risk Management Plan) for alignment.

- Identify and analyze product and project interface risks such as incomplete interface specifications, availability of commercially available components, inadequate team interfaces etc.
- Schedule the tasks in a sequence that accounts for critical development factors and project risks
- Objective entry and exit criteria for major project tasks to authorize the initiation and completion
- Compatibility of the plans with the plans of relevant stakeholders.

9.6 Review Project Management Plan

PM organizes a plan review meeting to discuss the details of all the project plans and assignments and obtain commitments of the project stakeholders. Representatives from all related departments attend to the review meeting.

PM is responsible for updating the Project Management Plan (PMP) to reflect the review results. The PM also ensures that all related development plans are updated.

9.7 Project Kickoff meeting

The PM arranges a project kick-off meeting involving all the project team and reviews the scope and objectives in the meeting.

9.8 Project Execution

9.8.1 Monitor and Control the Project

During the execution of the project, the PM monitors the project progress, resolve issues by taking corrective actions and coordinate the stakeholders in accordance to the Project Management Plan.

Project monitoring and control is achieved by:

- Progress review meetings,
- Progress reporting,

9.8.2 Conduct Progress Review Meetings

The PM organizes progress meetings after the completion of each project milestone. All stakeholders of the project attend to the milestone progress meetings. The PM prepares Project Progress Report before the meeting and distributes the report to the stakeholders of the project.

The PM ensures that the following issues are discussed during the Milestone Progress Meetings:

- Status of the project from the following perspectives: schedule, effort, quality
- Status of the project risks
- Issues related to coordination and communication and/or involvement of stakeholders
- Subcontract management issues (if applicable)
- Other issues raised
- The PM ensures that project status information is communicated regularly to the following stakeholders through reports or meetings:
- All the team leaders
- End users,
- Customers,
- Suppliers

9.8.3 Prepare Progress Reports

The PM is responsible to prepare project progress reports at the intervals defined in the PMP. The project progress report is distributed to all project stakeholders.

9.9 Project Change Management

Any change to the project is communicated to the PM through Change Request form. All changes are recorded in Change_Request_Log_Template.

The PM will evaluate the change request and may perform one of the following activities. The PM records the decision and/or the rationale on the change request form.

- REJECT the change – if it is a major out-of-scope request. In this case the department requesting the change can initiate a project cycle using Project Proposal Form.

- ACCEPT and execute the change – if is a minor change that does not affect the project schedule. In this case the PM also assigns one or more members of the project team to implement the change.

- FORWARD FOR EVALUATION – if the PM cannot decide the scope and impact of the change then s/he will forward the change request to project team members for evaluation.

If the change request is forwarded to the project team for evaluation; the team performs an impact analysis and makes a decision based on the following rules. The project team records the results of the impact analysis and/or the decision and/or the rationale on the change request form.

- If the change request can be implemented within the project schedule with additional effort then it is the project team's decision whether to implement or not. In this case the PM and/or team leaders assign appropriate team members to implement the change. The PM may also need to change the project plan to reflect the implementation activities.
- If the change request has an impact on the budget and/or on the schedule of the project more than 10% then it is forwarded to the Change Control Board for a decision.
- If the project team cannot make a decision on the implementation of the change request, then it is forwarded to the Change Control Board.

The Change Control Board makes the final decisions regarding to the incoming change requests. The PM records the decisions and/or the rationale on the change request form and is responsible for the execution of the change.

After the implementation of the change request, the PM closes the change request and informs the initiator.

9.10 Project Closure

- The PM closes the project when the closure conditions defined in the PMP are satisfied and production approval document defined by Quality Department is approved by related departments.
- The PM prepares a Project Closure Report that includes information from individual team closure reports, the results of Project Closure Meeting, as well as project measurements.

10 DORO's Design Process Activities

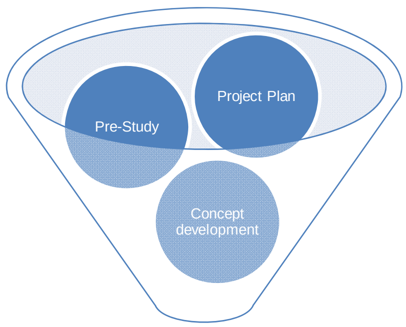
The following section provides an overview of the product development process as performed at DORO.

Doro Design
Development process

Document name:	Design process
Version:	4
Approval date:	2010-08-10
Approved by:	TBL
Replace version:	3
Issued date:	2010-08-09
Total number of pages:	8

2010-08-10 Doro Design process v4- Confidential

Doro Design process

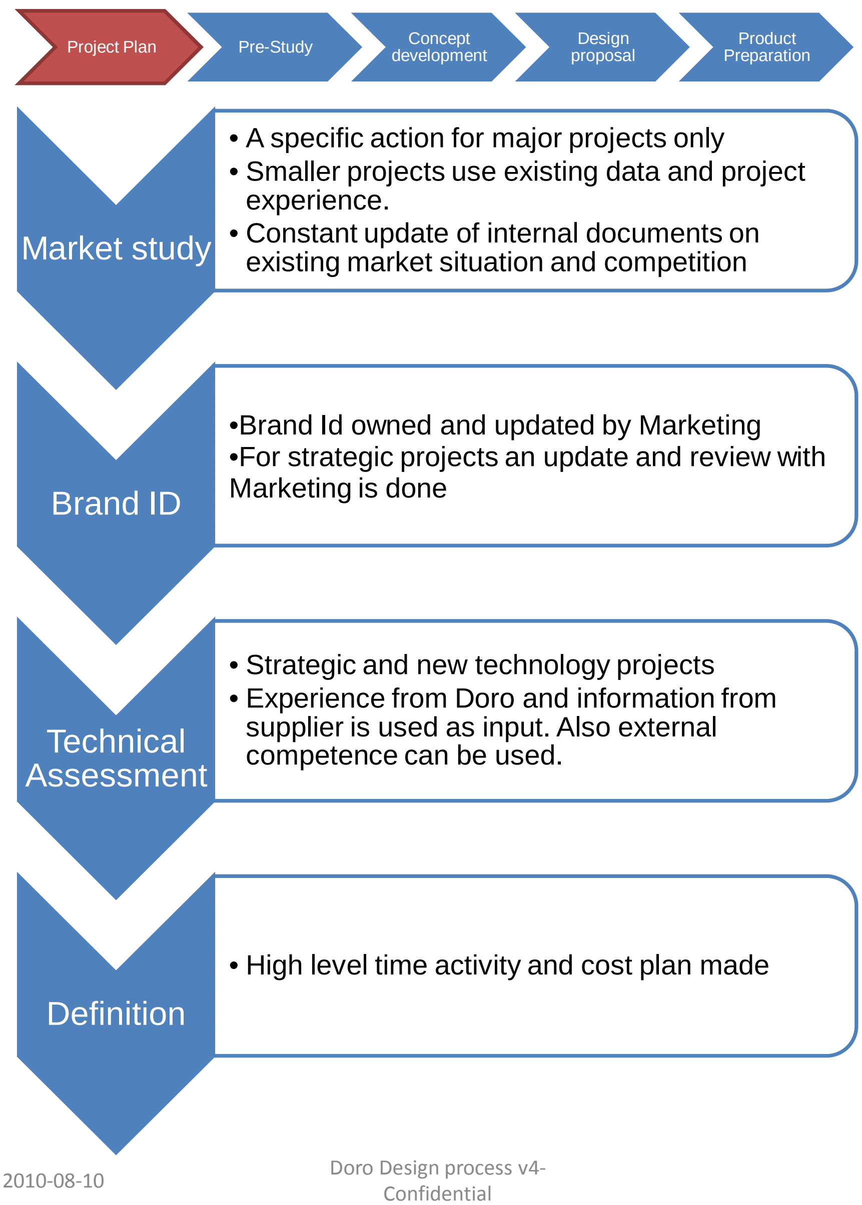


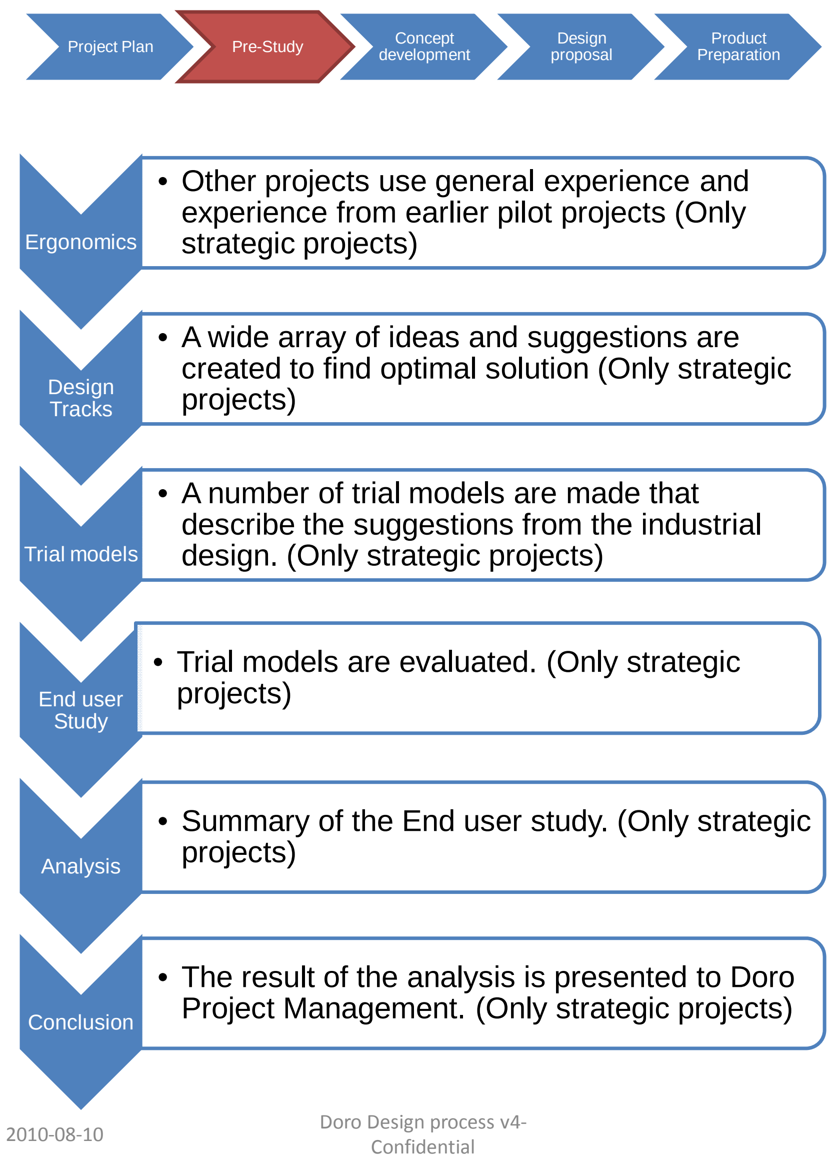
Design proposal

Production preparation

2010-08-10

Doro Design process v4-
Confidential


Project Plan
Pre-Study
Concept development
Design proposal
Product Preparation
Market study
• A specific action for major projects only
• Smaller projects use existing data and project experience.
• Constant update of internal documents on existing market situation and competition
Brand ID
•Brand Id owned and updated by Marketing
•For strategic projects an update and review with Marketing is done
Technical Assessment
• Strategic and new technology projects
• Experience from Doro and information from supplier is used as input. Also external competence can be used.
Definition
• High level time activity and cost plan made
2010-08-10
Doro Design process v4-Confidential


Project Plan
Pre-Study
Concept development
Design proposal
Product Preparation
Ergonomics
• Other projects use general experience and experience from earlier pilot projects (Only strategic projects)
Design Tracks
• A wide array of ideas and suggestions are created to find optimal solution (Only strategic projects)
Trial models
• A number of trial models are made that describe the suggestions from the industrial design. (Only strategic projects)
End user Study
• Trial models are evaluated. (Only strategic projects)
Analysis
• Summary of the End user study. (Only strategic projects)
Conclusion
• The result of the analysis is presented to Doro Project Management. (Only strategic projects)
2010-08-10
Doro Design process v4-Confidential


Project Plan
Pre-Study
Concept development
Design proposal
Product Preparation
Project Planning
• Time and cost plans are detailed
Creative stage
• Different concepts and solutions are brainstormed to identify detailed direction
Workshop
•Choices are made based on creative stage phase. (Only in medium size or major projects)
Concept for design
• Details in the identity and mechanical design are studied to secure feasibility.
• The design is coordinated with corporate identity.
• Colour suggestions, graphics and materials are suggested
Harmonisation
• Evaluation of the selected concepts regarding design, functionality, industrialisation potential, ergonomic quality.
Illustration
• Scale models in 3D and correct scale for user tests. (Only strategic projects)
• Description of appearance and finish. (Only strategic projects)
User tests
• Scale models are used. (Only strategic projects)
Analysis & Evaluation
• Result from User tests are analysed and evaluated. (Only strategic projects)
Conclusion
• Result are presented for Doro Project Management.
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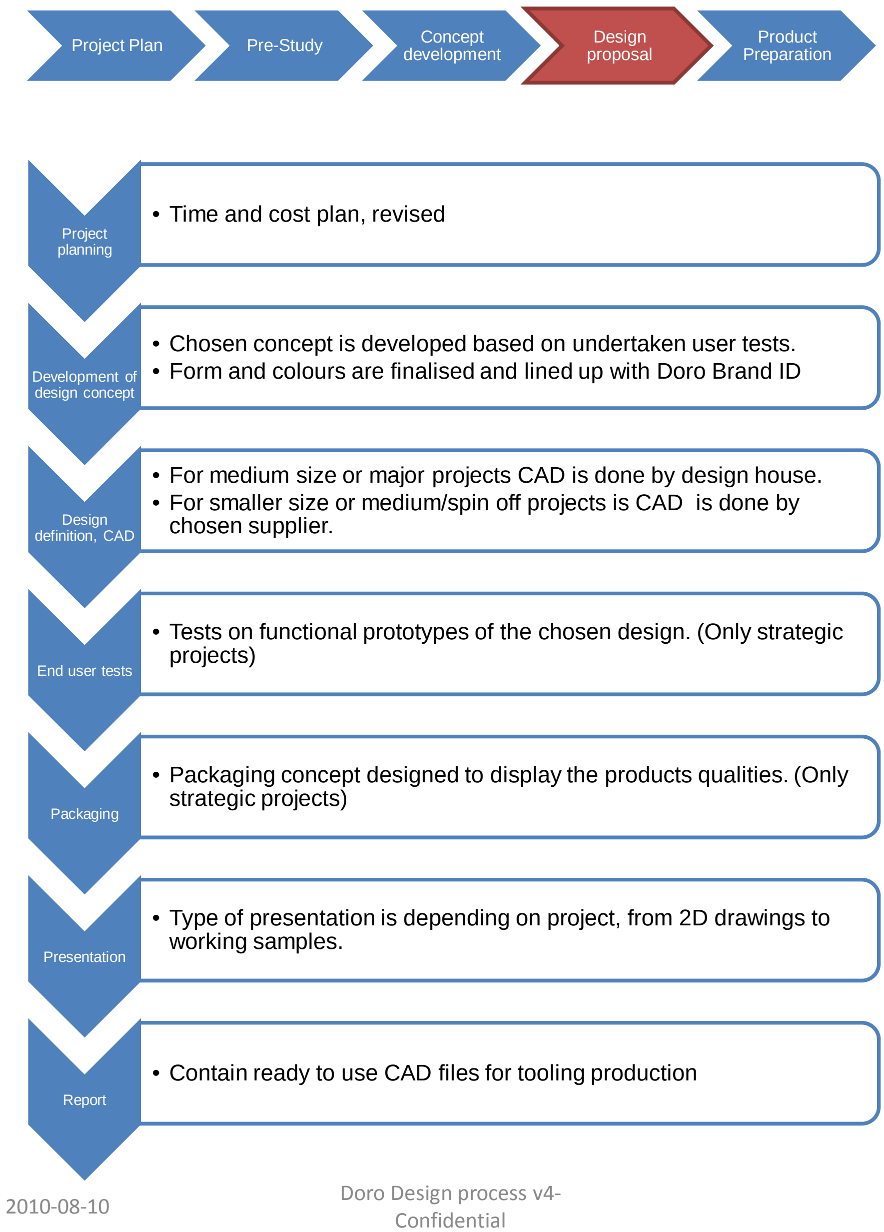
Project Plan
Pre-Study
Concept development
Design proposal
Product Preparation
Project planning
• Time and cost plan, revised
Development of design concept
• Chosen concept is developed based on undertaken user tests.
• Form and colours are finalised and lined up with Doro Brand ID
Design definition, CAD
• For medium size or major projects CAD is done by design house.
• For smaller size or medium/spin off projects is CAD is done by chosen supplier.
End user tests
• Tests on functional prototypes of the chosen design. (Only strategic projects)
Packaging
• Packaging concept designed to display the products qualities. (Only strategic projects)
Presentation
• Type of presentation is depending on project, from 2D drawings to working samples.
Report
• Contain ready to use CAD files for tooling production
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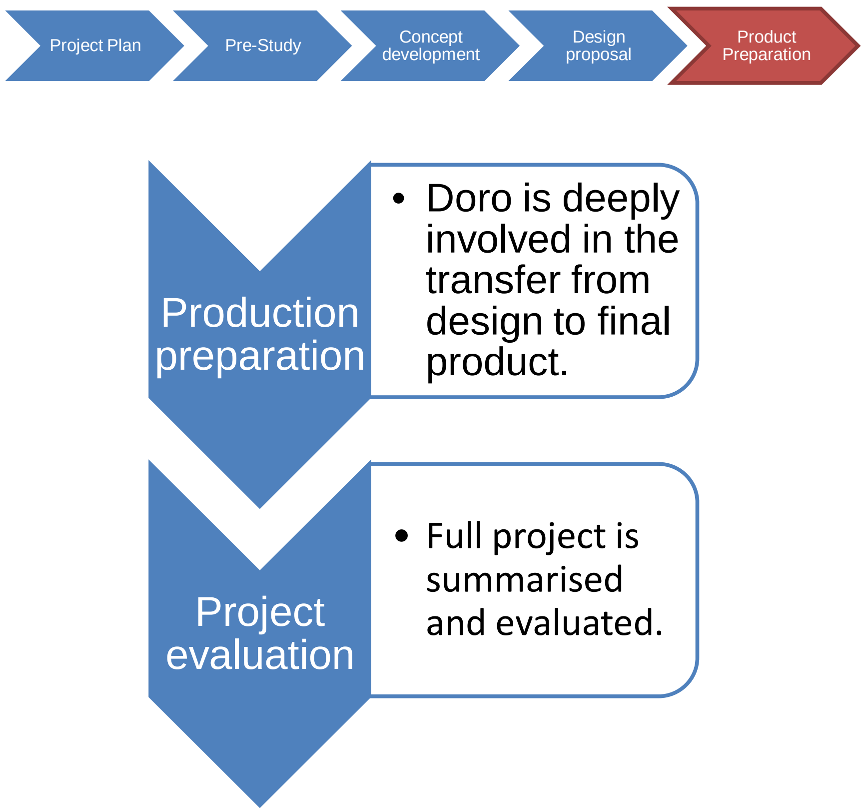

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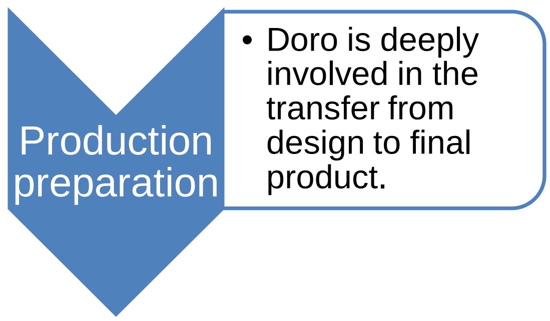

Project evaluation

- Full project is summarised and evaluated

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