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HOW TO DIGITIZE ANALOG INDUSTRIAL DESIGN ENGINEERING

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1. Introduction

Progress means change. In both, mechanical design engineering and education, technical progress indicates many important deciding changes. For example, product engineering without modern computing technologies and computer aided drawing got unthinkable within the last ten years. This development results on the fact computing technology evolution is getting faster and cost lower. In addition to this trend, useful hardware and software tools has been developed and give a comprehensive support in the whole product development process. An example for such supporting software is the finite element analysis (FEM) or the computational fluid dynamics (CFD).
Another aspect in the world of modern engineering is the increasing globalization followed by the decentralization of the product development. Consequential, networking around the whole world isn't only luxury but also necessary for a successful product development. As an example, the Digital Mechanism and Gear Library (DMG-Lib) is a digital, internet-based library which provides an efficient access to a knowledge space of mechanism and gear science [Brix 2007]. With this library research and development of gears can be supportet all over the world and as a result the developed knowledge out of it can be transferred back to this library and communicated to the researching community.
Although networking-based development and data exchange is common in mechanical product development it is at the moment not applied in industrial design engineering. In this contrast, the traditional industrial design engineering is already integrated in technical product development. Figure 1 shows the correlation of production, mechanical and industrial design engineering development as explored at the research and teaching department Industrial Design Engineering [Götz, 2007].

2. The comprehension of modern Industrial Design Engineering

In order to realize the difficulty and the capability of the procedure of modern industrial design engineering it's important to give an example for the traditional procedure. This procedure is already integrated in existing development structures and can be described with help of the general design methodology according to VDI 2221 [VDI, 1993] which is structured in four phases: The planning, the conceptual design, the embodiment design and the detail design (as shown in figure 1).

2.1 The traditional procedure

In the planning (first phase) for the respective problem e.g. creating a new technical product several ideas are collected in collaboration with the customer based on an analysis of the market situation and by defining the requirements list. According to this, the first ideas are collected in the form of textual

characterization or handmade outlines. Required skills and competence in this phase are technical comprehension concerning the respective problem and creative ability.

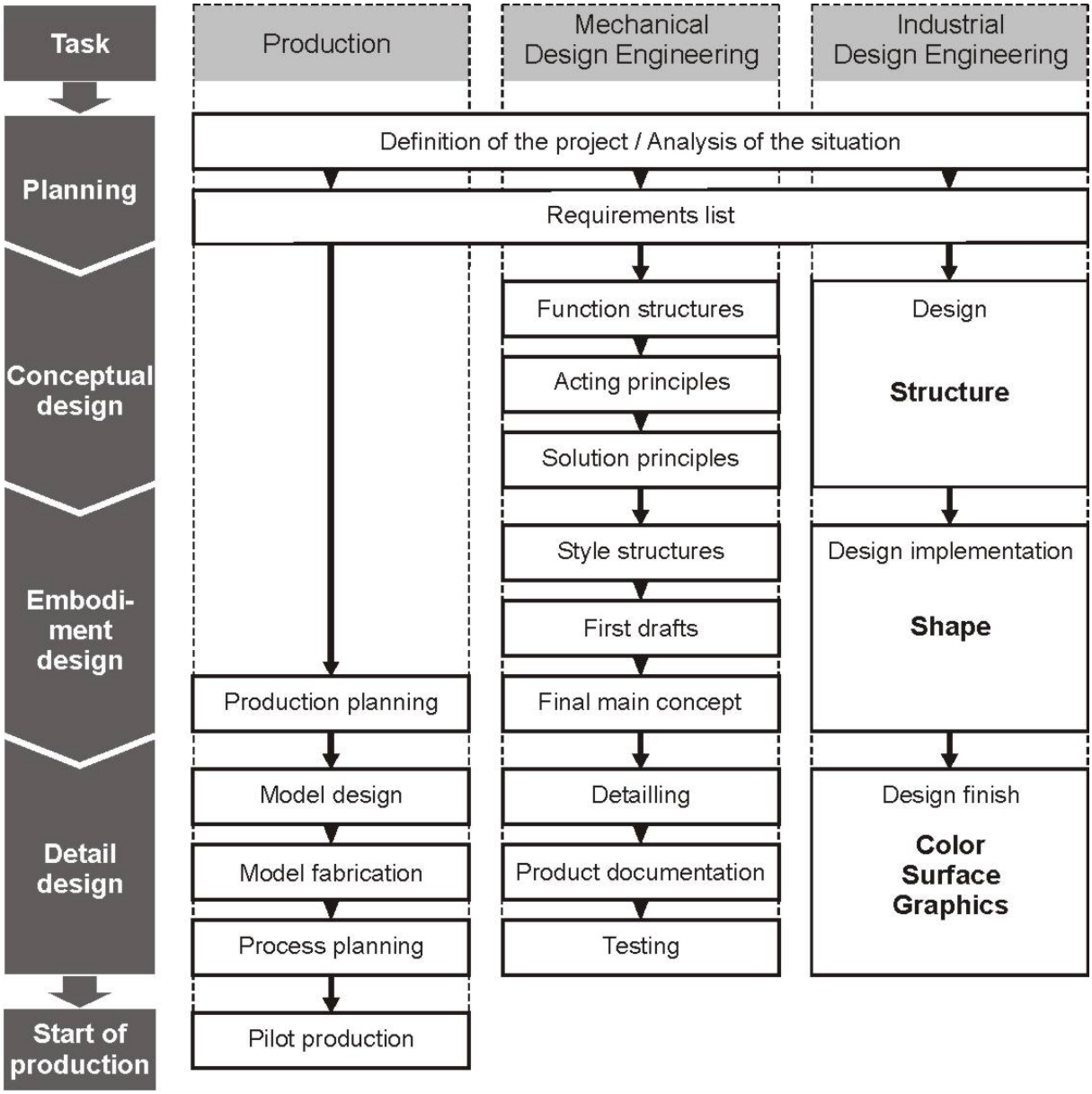

Figure 1. Integrated industrial design engineering according to [Götz 2007]

With these ideas some first drafts are made in the conceptual design (second phase). These drafts are also drawn on paper and require good drawing competence. Analysed and evaluated build these drafts a good starting basis for generating concepts. In contrast to the drafts, concepts are more detailled and include not only acting principles but also solution principles and single structures. Because these concepts are also fit with colored accents which requires drawing and coloring competence. After the evaluation of these concepts at the beginning of the embodiment design (third phase), the final concept can be build up. By now this colored concept is highly detailled and an important milestone and decision-maker. As technical realization and comfort is the importest issue for a sellable technical product, professional knowledge is more important than artistic skills at this step. Based on the final concept, now a physical model can be built up at the end of the embodiment design. This model is fully handmade and usually consist of the modeling basic material clay. To reach an optimal result, modeling competence is absolutely necessary for this step of the product design development because with this physical model the design review can be executed. In this meeting the physical model is

briefed by all important decision makers belonging to the whole project. Mostly the customer is present in this meeting so that the customer-to-customer principle is fullfilled.
After the modifications resulting of this review, detail drawings can be generated at the detail design (fourth phase). At this step good engineering competence is the key factor regarding producibility and technical realization. On the base of these detail drawings a prototype can be build up and the product can be inspected and tool-planning for manufacturing can be started.
Advantages of the traditional way of industrial design engineering are the haptical feedback while working with traditional tools and the personal perception effected by a handmade scetch or physical model. In this context, stylists are talking of the "charm of a handmade outline" [Daimler 2008]. In addition, research to handmade outlines have resulted that the creative and problem solving process is supported within the iterative working by generating more detailed drawings from scetches and models by hand and not automatically [Hacker, 2002].
Disadvantages of the traditional industrial design engineering are the unexact reproducibility of handmade physical models and the communication barriers on far distances.

2.2 Applying modern media

Regarding to the disadvantages of the traditional way of engineering, modern engineering got nowadays unthinkable without computer media. The reason for this trend is found in the evolution of computing technologies within the last ten years: The performance of computer hardware and software got better and cost less. Another trend is the increasing networking around the whole world because an advantage of this computer- and network-dominated engineering is an efficient communication and online data exchange between the several development partners. So while computing technologies are getting better, online communication increases and results in turn better and efficient product development. Therefore knowledge and results of research and development can be used by every development partner even if they are widespread over the whole world or simply one country. The biggest benefit resulting of these advantages of a wise application of digital media is less development time because of this effective communication [Beier, 2009].
Based on this knowledge, the procedure of the traditional industrial design engineering could be proceed in the computer-dominated engineering with current digital media and software. In the following a short introduction in modern media is given. For this regarding, it's essential to differentiate hardware components which are restricted to physical tools and software components which are required to run these physical tools.
The main hardware inside this procedure is a usable personal computer (PC) and a functional network connection. The PC includes the main processing unit and several output devices (screen, speekers) and input devices (keyboard, mouse and others). A special input device for industrial design engineering is a digital drawing board for generating digital drafts. A virtual reality system for design development review is a hardware unit for visual output tasks. Whereas, a rapid prototyping machine for producing the physical model with free-form surfaces is a hardware unit for physical output within the modern development procedure.
Required software for an usable PC is an operating system and communication or messenging software. Special graphic programs for sketching and computer-aided drawing are necessary for creating the data for the digital mockup. Using the virtual reality system, a special virtual reality software is needed as well as computer-aided manufacturing-software to translate the digital data into a machine code for manufacturing on the rapid prototyping machine.
For all that, personal skills and experience in design are more important for understanding the principle of modern systems and software. Secondary, knowledge is definitely necessary for using the many different digital media and software systems. Hence, it is not possible to use the computing systems for engineering without being instructed by a professional. So in contrast to less development time because of an effective communication within the engineering process is the additionally effort to learn the systems and software.

3. A challenge called Digital Design Process

The application described in chapter 2.2 defines the starting basis of modern industrial design engineering. It shows a simply integration without adaption of the methodology but considering new possibilities of engineering. Concerning this, it was needful to make an analyze of this starting basis regarding advantages and disadvantages of a direct application.

3.1 Analyzing the procedure with applicated media

For the last years several research and confrontation between the traditional and the modern procedure regarding advantages and disadvantages have been generated. As an example, the research of Fritz Küderli [Küderli, 2007] is especially focused on the expenditure of time and was demonstrated with the exterior design of a car. Unfortunately, a direct comparison based on the equal technical problem and design step isn't found within his research and the research of many others.

Therefore and because of the high complexity of this procedure, an own comparison of the traditional and the modern procedure of industrial design engineering was executed [Iwanitza 2008]. As a practical technical problem for this research the interior design of a baking oven has been selected because all three slittings of product development (as shown in figure 1) could be processed. Fortunately, the same development was already realized with the traditional engineering thirteen years ago [Schmid, 1995]. According to this fact, a basis for comparison was given. This comparision of the traditional to the modern procedure is shown in figure 2 and will in the following be explained in its result.

In the planning (first phase) the creativity process for example like brainstorming or searching for requirements can be performed not only at one place but it can be done in a kind of online meeting with special online software and networking. The advantage is the more spontaneous possibility of such an online workshop, the real-time data exchange all over the world (which is also an advantage in every phase of product development) and less time and costs for travel. Regarding the last point, online meetings got a big environmentally friendly aspect than the traditional way. The disadvantage is the more anonymous communication via messenging system which results in less personal contact with the other team members.

In the second phase (conceptual design) first concepts can be generated with CAD software. With these more detailed data, first ergonomic studies can already be realized in this early phase of the development procedure. From this follows that the concepts are from the beginning more exactly and reasoned. The work and costs of change in later phases minimizes thanks to the early CAD models. Not only ergonomic studies but also package layouts and assembly volumes can be integrated in early digital models. The disadvantage of these early CAD models is the more expenditure of time because CAD software is difficult. Learning these software is because of its complexity also very time-consuming and do not support the native and familiar way of modelizing.

In the embodiment design (third phase) the advantage of the traditional phase is intuitive modelizing. By modelling the concept with his hands, the designer has the haptic control of all surfaces and edgings. In addition, freehand modelizing is a very native way to create something from mind. Just as freehand scetching, freehand modelizing is a very familiar way of creating things. Designing the concept with CAD software doesn't give any haptical feedback to the designer so that controlling the surfaces got more difficult because the visual feedback on screen is not sufficient.

In the detail design (fourth and last phase) the expenditure of time while generating CAD models in the conceptual design redounds to advantage because with a more reasoned and well-thought-out CAD model at the end of the embodiment design detail drawings and process planning get more easier and faster.

With regard on the whole process, it can be concluded that skills traditionally required are more sensual and manual. Whereas, the required skills within the modern development are depending on knowledge about computing technologies and demand a structured procedure from the first moment in development.

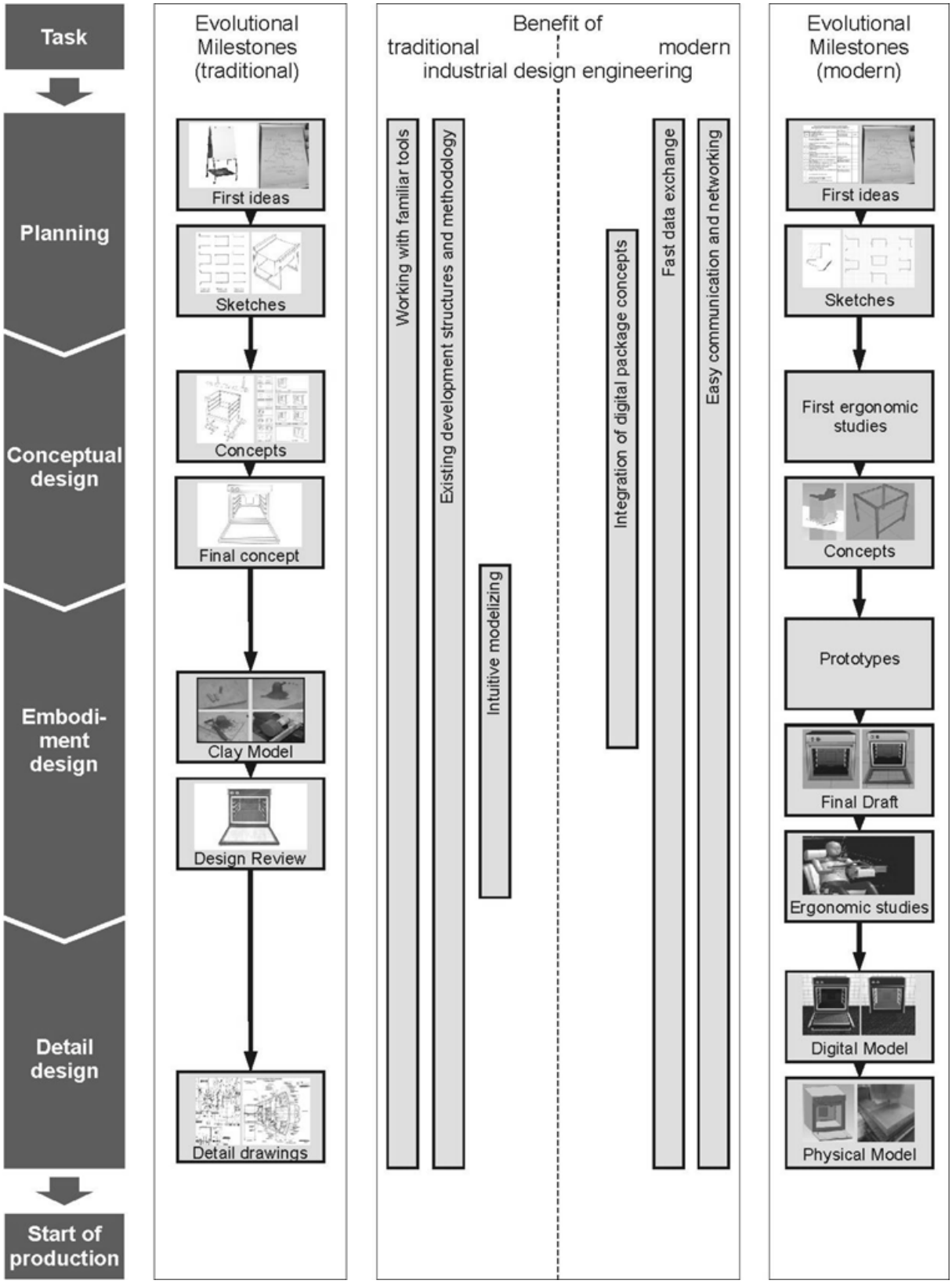

Figure 2. Traditional procedure in comparison to modern procedure

3.2 Selecting requirements to the Digital Design Process

Regarding the last research concerning the integration of traditional industrial design engineering in the computer-dominated mechanical design engineering, it can be seen that single steps of the traditional procedure are directly applicable with digital media. But during this application several issues appears. These issues are divisible in possibilities and challenge (see figure 3).

The possibilities are derived from the advantages of combination of the general design methodology according to VDI 2221 [VDI, 1993] and the usage of modern digital media within the industrial design engineering. A more efficient communication as already described in chapter 2 is the most longing benefit as well as the transfer of knowledge all over the world. Another possibility is the early prototyping. These kind of prototypes are different to those resulting of the traditional procedure because the quality of these models is higher and reproducibility based on digital data is possible. Equally, changes can be fit on these data and this results in a completely documented development which can be used in later projects as reference. The implementation of ergonomic studies in an early phase deliver essential facts for the following product design development. If the requirements of personal comfort are integrated as early as possible the final concept will be more detailled in important selling reasons like customer acceptance and product attractiveness.

To reach these advantages, it is necessary to integrate digital media within the industrial design engineering. The challenge of this integration with the help of a new methodology is the main issue of my research at the research and teaching department Industrial Design Engineering.

First of all, it will be essential to create personal competence for digital media. In a conservative profession the experience with modern media is less especially by older generations. As a result, the education in digital media in this conservative profession is also affected by research and less know-how. A modern education in digital media would reach better media competence and as a result worldwide user acceptance. In many styling schools the digital drawing board is already part of the curriculum but other important media like analyzing and designing software isn't detailed and widespread in education.

Another main point of the challenge is to abolish interface incompatibilities. These incompatibilites between different software appears for example at the transformation of a digital freehand sketch done with graphic software to a three dimensional digital model of engineering software. With the current state of the art it is not possible to create the model just with the digital freehand sketch. There exists many facilities and tools which allows the redevelopment of already existing drawings but no possibility for an exact transfer [Iwanitza, 2008]. According to [Hacker, 2002] and others, it may be not necessary for the origin designer to create a model automatical basing on scetches. But regarding the whole technical product development and the different professionals working in this development it will be great help and support for an engineer if "soft" scetches from a designer can be transformed in "hard" data material usable. This fact was already shown in projects and researches and in addition, the better integration of industrial design engineering in technical product development is still requested in the modern world [Wüsthoff, 2009]. As one example, special ergonomic software like RAMSIS can be apllied on the "hard" data material but not on design scetches. But nowadays, even with already generated digital data material additional incompatibility appears by using ergonomic software tools because the transformation of the three dimensional digital model to an ergonomic model should be not only unidirectional like former transformations. These transformations have to be bidirectional because changes within the ergonomic studies should also be applied in the digital model. The third main incompatibility builds the transformation of CAD (computer-aided drawing) to CAM (computer-aided manufacturing) data. Current software is already able to transform these data on the direct way but there are in many cases still additional protocol converters and iterative controlling cycles necessary.

All these described interface incompatibilities are not only a software problem. Fortunately, the software manufacturer upgrade their products at regular intervals to abolish incompatibilities within the own product line-up. On the other hand, between products from different software producers barriers because of incompatibility and different formatting still exists because there exist no unique data exchange format in which the virtual models can be manipulated and used in other software tools as been constructed directly in these tools.

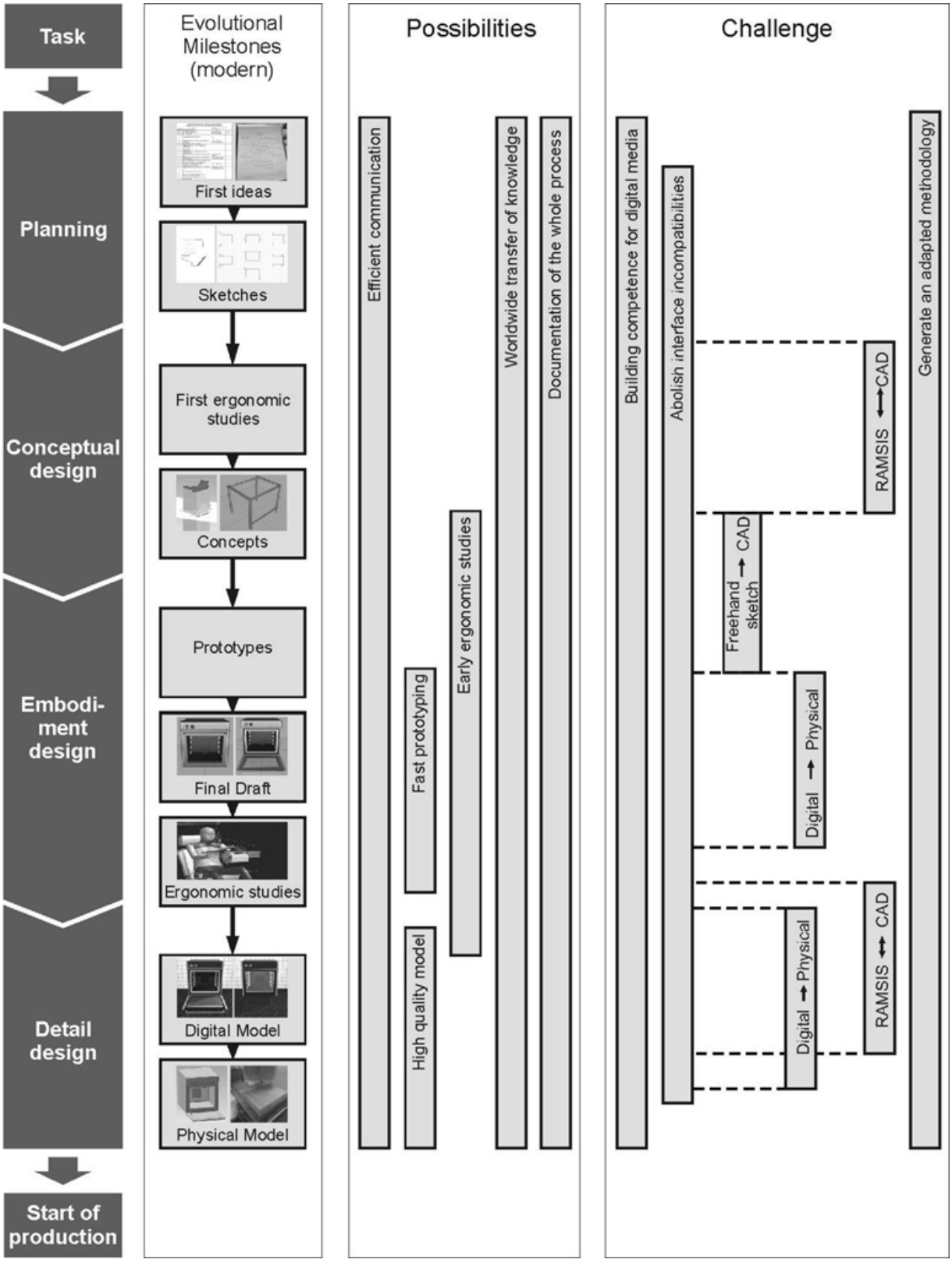

Figure 3. Possibilities and Challenge of digital media

4. Conclusion

Regarding the analysis of first implementations, modern industrial design engineering cannot be solved by generating more and more new software tools and hardware components. An adapted methodology will be the key issue to win the accepted challenge. For example, software incompatibilities would be less of consequence if the industrial design engineering methodology gives an approach for a software-independent development. Without an adapted methodology, the described possibilities may negate and convert to disadvantages at the worst. So, the aimed methodology will be the important factor for a successful and effective product development and has to be evaluated by appliing in several technical projects. These projects have to be different in its content and area of activity to result a widespread evaluation.

References

Beier, F., Maier, T., Innovationen im Designprozess – Über den sinnvollen Einsatz digitaler Medien, Innovation durch Design, Dresden (Germany), 2009, pp 133-145

Brix, T., Döring, U.; Reeßing,, M. The Digital Mechanism and Gear Library as a Tool to support the Engineering Designers Work, in Knowledge, innovation and sustainability, Proc. International Conference on Engineering Design, ICED '07, Paris (France), August 2007, pp 251-252

Daimler AG, Daimler HighTech Report 01/2008, Stuttgart (Germany), 2008

Götz, A.; Maier, T., An adaptive product development process for engineers and industrial design engineers, in Knowledge, innovation and sustainability, Proc. International Conference on Engineering Design, ICED '07, Paris (France), August 2007, pp185-186

Hacker, W., Denken in der Produktentwicklung, vdf Hochschulverlag AG, ETH Zürich (Switzerland), 2002

Iwanitza, A., Untersuchung zum Designprozess unter Anwendung eines digitalen Zeichenbretts (Wacom Board), Study, IKTD, University of Stuttgart (Germany), 2008

Küderli, F., Computer Aided Styling und die virtuelle Realität im Außen- und Innendesign, Automobildesign und Technik, Vieweg und Teubner Verlag, Wiesbaden (Germany), 2007, pp 302-314

Schmid, M., Konzeption eines Backofenbaukastens in Modulbauweise für mittlere Serienstückzahlen, Study, IKTD, University of Stuttgart (Germany), 1995

VDI 2221: Systematical approach to the development and design of technical systems and products, technical guideline, Verein Deutscher Ingenieure, Düsseldorf (Germany), 1993

Wüsthoff, T., Hirzinger, G., Integration von Produktdesign in Entwicklungsprozesse der angewandten Forschung, Innovation durch Design, Dresden (Germany), 2009, pp 221-235

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