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# INTEGRATED PRODUCT DEVELOPMENT AS A KEY TO SUSTAINABLE PRODUCTS

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## Abstract

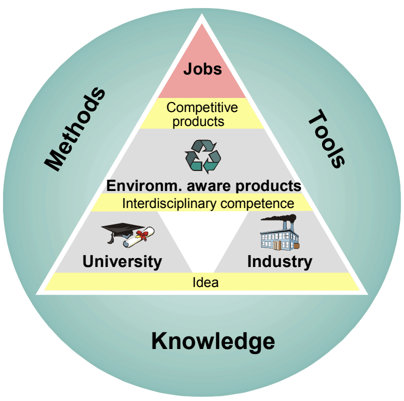
Following the rules of Integrated Product Development (IPD) will lead to competitive and sustainable products. In a practical case study it is shown that the consequent use of design methods and computer support of design combined with interdisciplinary team work can help to find still a potential for innovation even at well developed products. The potential and the benefits of this approach could be demonstrated in a pilot project with a vacuum cleaner. By realization of a prototype fit for use the potential for innovation and the improvement of sustainability could be shown in detail.

*Keywords: Integrated product development, design-for-X, sustainable design*

## 1 Introduction

The approach of integrated product development is a base for developing products which can be successful in the market. It allows also the improvement of products which seem to be squeezed out in their development and are said to have no further potential for steps forward. On the other hand "Design for environment" is an extremely complex approach which asks for the fulfilment of a great quantity of restrictions. Therefore the development of sustainable products leads nearly automatically to market oriented products. Therefore the intention of the case study described here is to demonstrate the potential which is hidden here, on the example of a vacuum cleaner.

## 2 IPD as a base for IPP



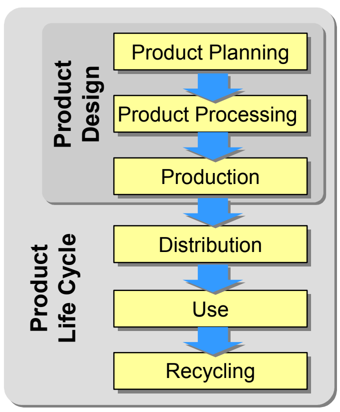




Figure 1: IPD as a base of IPP

Integrated Product development (IPD) is defined as an interdisciplinary, process oriented approach with a view on the total life cycle. It has to be seen as a combination of the use of design methods, tools based on information technology, a well adapted organisation and the acting people in the centre of all. Inherent there is a complex view in the interference between product (design solution) and the following processes.

Integrated Product Policy (IPP) is defined as a life cycle oriented approach leading to sustainable products. IPP understands a product as a comprehensive system with a look on the complete process sequence from the product idea and development, through the manufacturing and use, up to recycling and disposal of the product, combined with ecological, technical, economic, user based and social aspects.

The basic idea of this case study was to demonstrate the potential and the benefits of an IPD/IPP approach. This means not only following the view of total product life cycle but also a cooperation between industrial partners and university institutes. Working together in a team they will be able to solve the different problems and restrictions in reference to the development of sustainable products.

# 3 Working in an interdisciplinary network

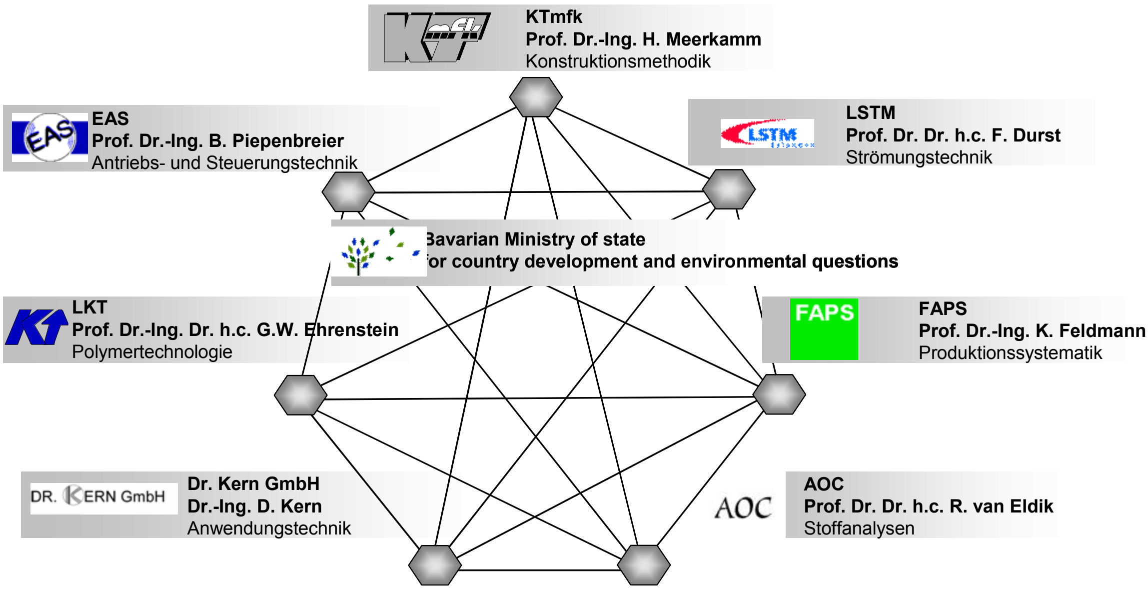



Figure 2: Network oriented approach

The network for the interdisciplinary team in this project was established by six university institutes and one industrial partner (SME). The competences combined and concentrated in this network were:

- engineering design
- fluid mechanics
- electrical drives
- polymer technology
- manufacturing automation and production systems

- anorganic and chemical analysis
- application techniques

These seven partners joined to a network called BEnefiT (Bavarian Development Network for Innovative Technologies). The two years longing research project was financed by the Bavarian State Ministry for State Development and Environmental Affairs. The members of this network brought in their special knowledge and their know how in handling and using special methods and tools. By this they guaranteed a powerful platform for predictive engineering.

# 4 The pilot project: vacuum cleaner

## 4.1 Methodical approach

A realization of IPP oriented products needs the IPD approach as an essential and powerful basis. With the development of a prototype of a sustainable vacuum cleaner it was our aim to make a practical embodiment of the IPP philosophy.

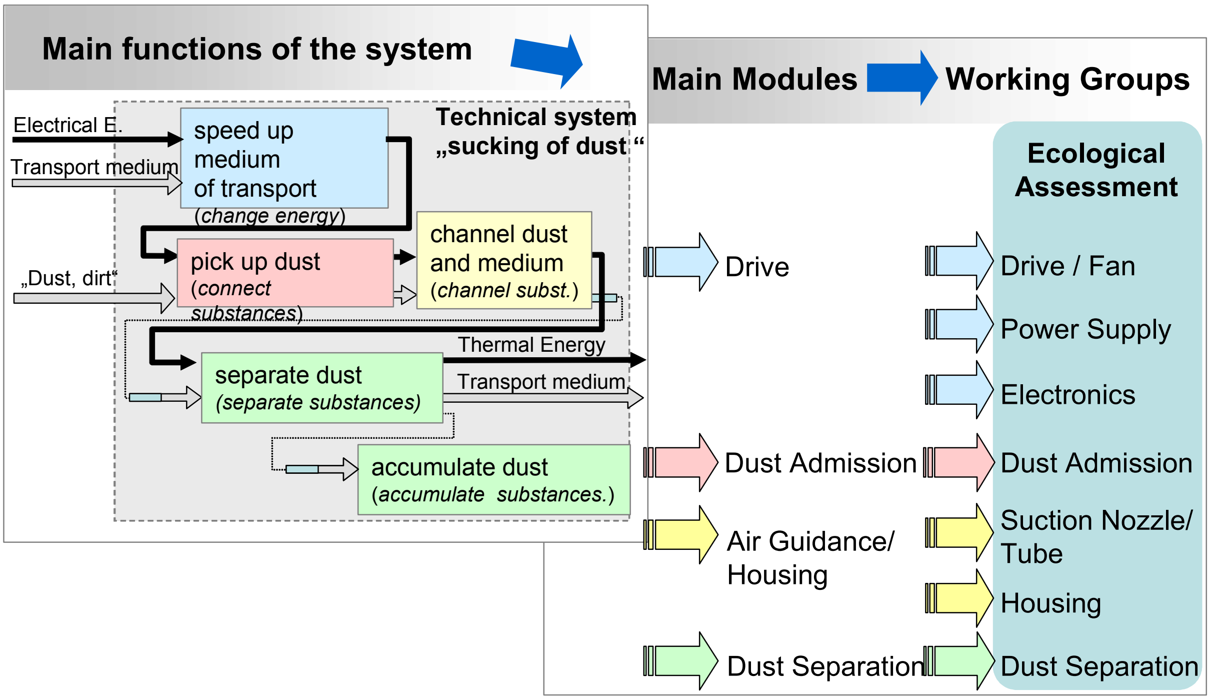



Figure 3: Method based approach (functions-modules-working groups)

Because of the high complexity of the problem (Design for sustainability means to fulfil at the same time the challenge of Design for X) and the demand for finding innovative solutions a design-method oriented approach was realized. Based on the requirement list a function structure was created, the main functions (e.g. speed up transport medium air, pick up dust, guide transport medium and dust, separate dust, store dust) by this defined the main modules of the vacuum cleaner. The working groups were declared responsible for the different main modules and according to the predominating physical base principles the members of the teams were recruited from the engineering design-, material-, analysis-, production and assembly-, and environmental field. The methodical frame was defined by the VDI 2221.

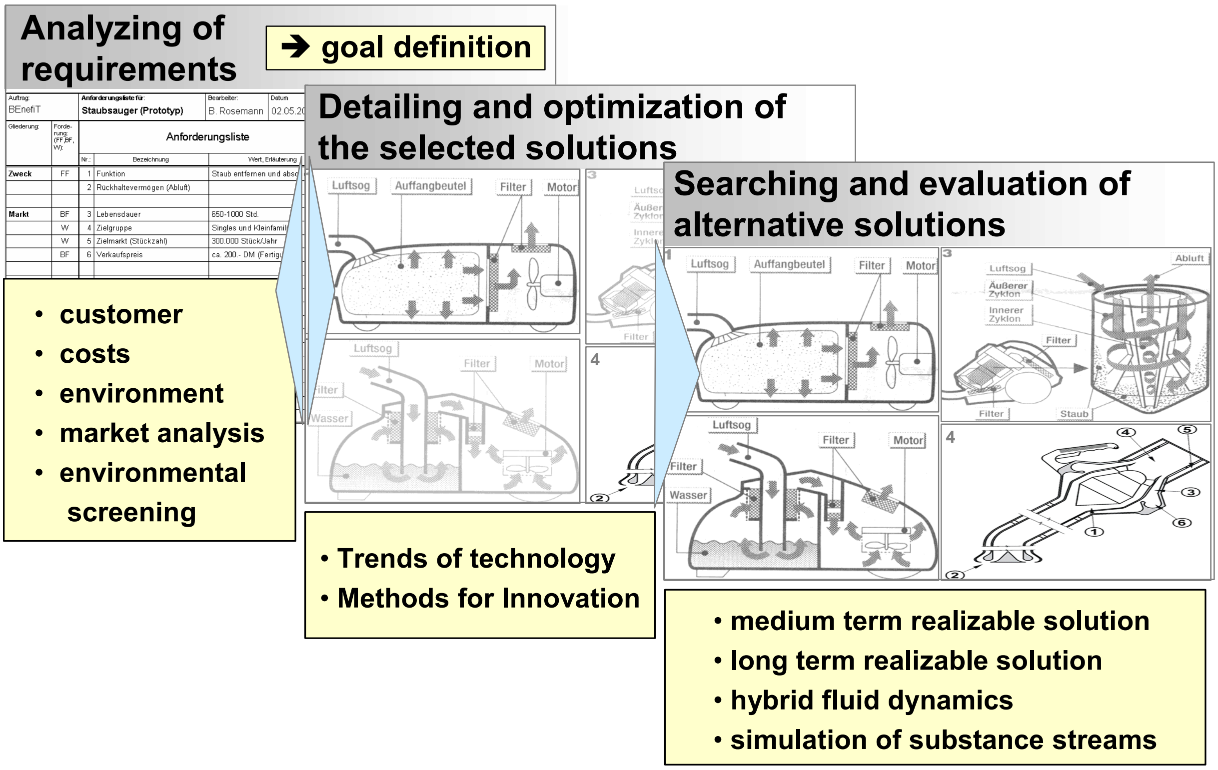



Figure 4: Proceeding in the working groups

Starting with a market analysis and an analysis of the requirements the goals of the project were defined at first, concentrating on the customers, the cost, and the environment. Based on the main functions the teams searched for alternative solutions which were to evaluate. The solutions selected on the base of a multicriteria evaluation were detailed and optimized in the next stage of the development process.

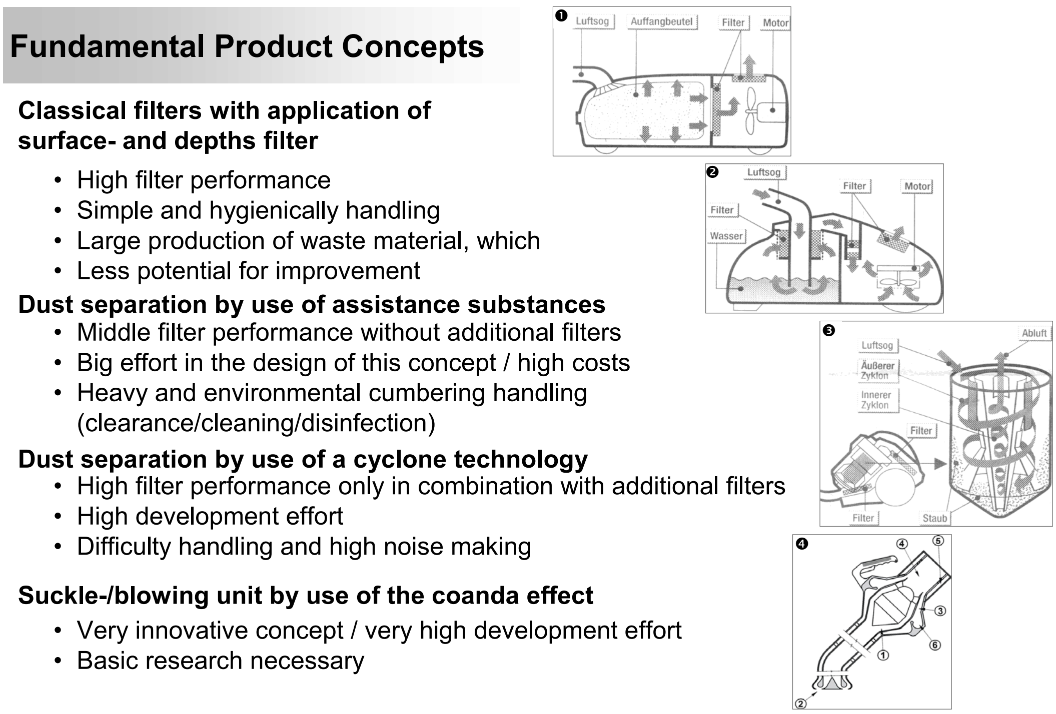



Figure 5: Product concepts – alternative solutions

As to the product concepts and the alternative solutions the teams looked as well for classical solutions as for extremely innovative solutions. Because of the limited running time of the project some innovative and most promising solutions could not be taken into consideration, as they still demanded a lot of basic research. E. g. the use of the coanda effect for the suckle-/blowing unit would have been promising but we did not choose this solution as there is still a lot research work necessary before one can practically use this effect.

## 4.2 IT-Tool based approach

In combination to the methodical approach the team used a great lot of actual IT-based tools for their development work. Tools like Tech Optimizer were used for finding innovative ideas when searching for physical effects and "Wirkprinzipien", the "Evaluator" was used for the multicriteria evaluation of the alternative solutions, different computer based simulation tools supported the investigations in the field of fluid dynamics and the molding processes of polymer technology, the Disassembly Graph was used for simulating disassembly processes. The Cumpan™ tool was used for eco-balancing.

In addition to these simulation activities there were a lot of experimental investigations to do. Material analytic with special laboratory equipment, optimization of the motor drive and the fan wheel of the blower on especially developed testing rigs are some important examples in this field. The 3-dimensional solid modelling with CAD allowed us a rapid prototyping for manufacturing three real and well operating prototypes. The combination of all IT-based activities, experimental work allowed us the approach of predictive engineering.

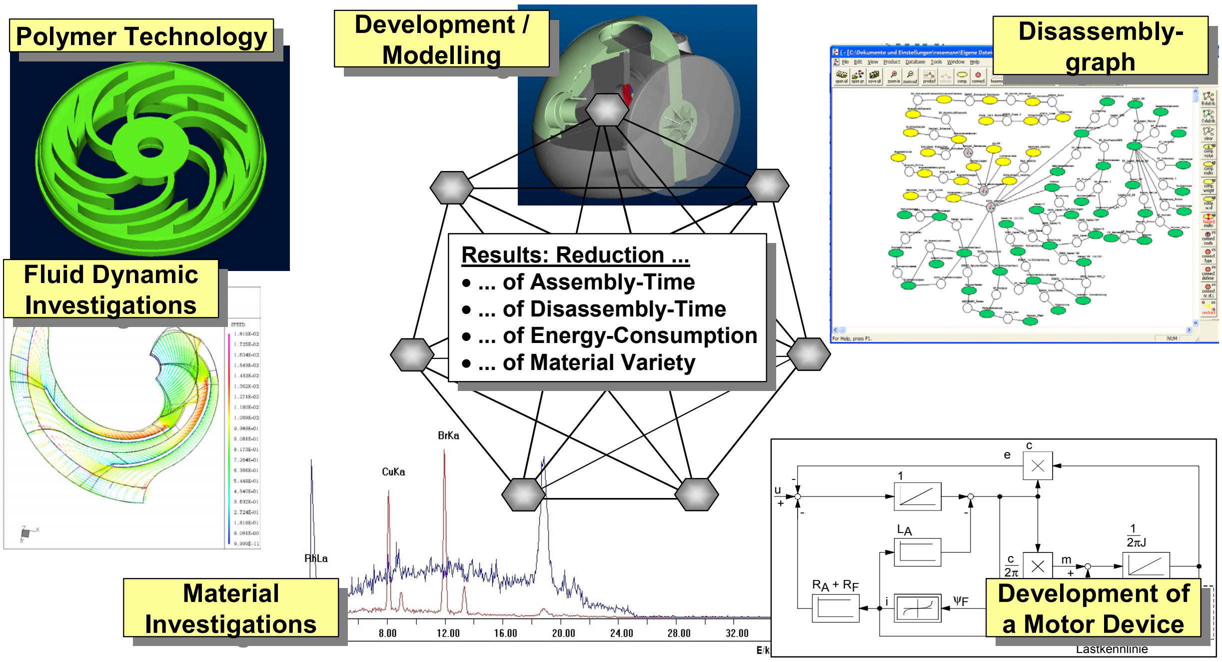



Figure 6: Predictive engineering in an interdisciplinary network

## 4.3 The prototype

The prototype of the vacuum cleaner which was realized in this case study distinguishes itself by a completely new electrical motor and blower concept. Both components are optimized together on behalf of a maximum of sucking power in combination with a minimum of energy consumption. Patents are applied for. The brushless motor (n = 35000rpm) with a high degree of efficiency (approximate 96%, nearly constant for the whole range of motor speed) does not need a special cooling device and no additional filtering system.

The housing is a one material solution (propylene PP) and can be recycled completely (100%). For better assembly and disassembly the product structure is based on two cover halves of polypropylene foam. All modules are inserted in a form tray of the cover halves. The cover halves are fixed together with a handle bar which integrates in addition the function of the wheel bearing.

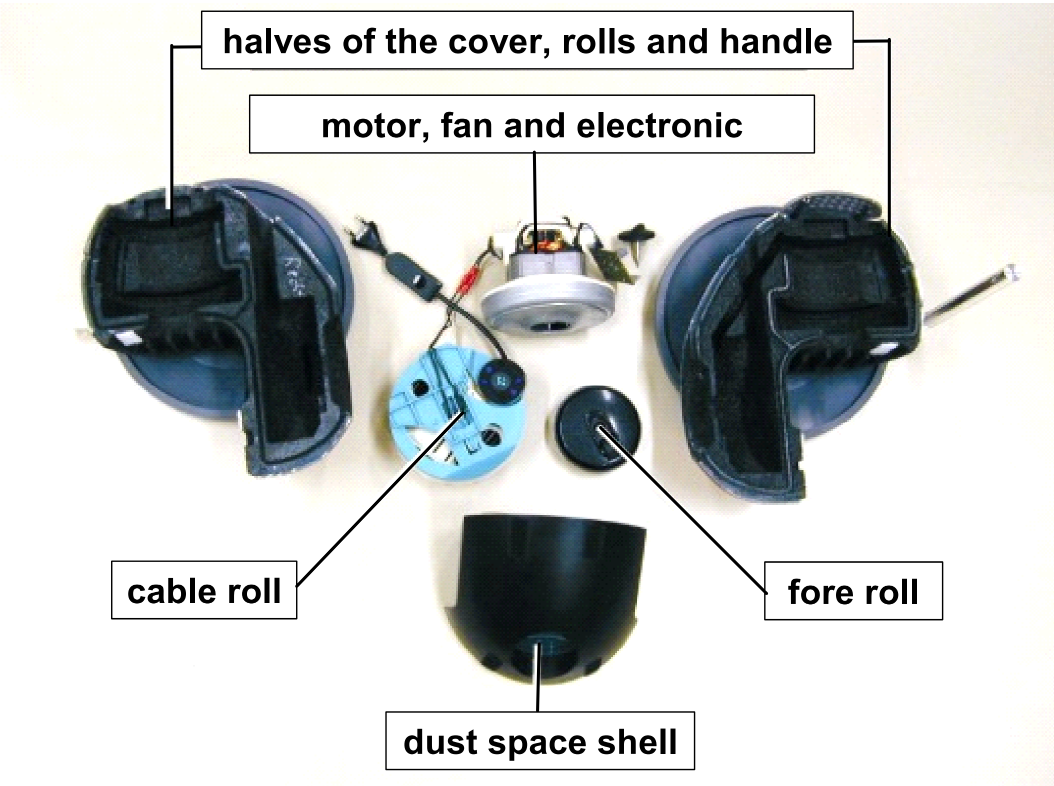



Figure 7: The prototype – internal structure

The properties and benefits of the BEnefiT-vacuum cleaner in comparison with a reference system in the market are shown in figure 8. This figure shows that we could reach a considerable reduction of power consumption, weight, disassembly time (which is an important factor for the recycling) and the number of materials.

The target costing postulated to position the prototype in the market segment with a price of approximate 100 Euros. This target could be reached in our theoretical calculations; the real selling price will depend on the actual conditions of manufacturing.

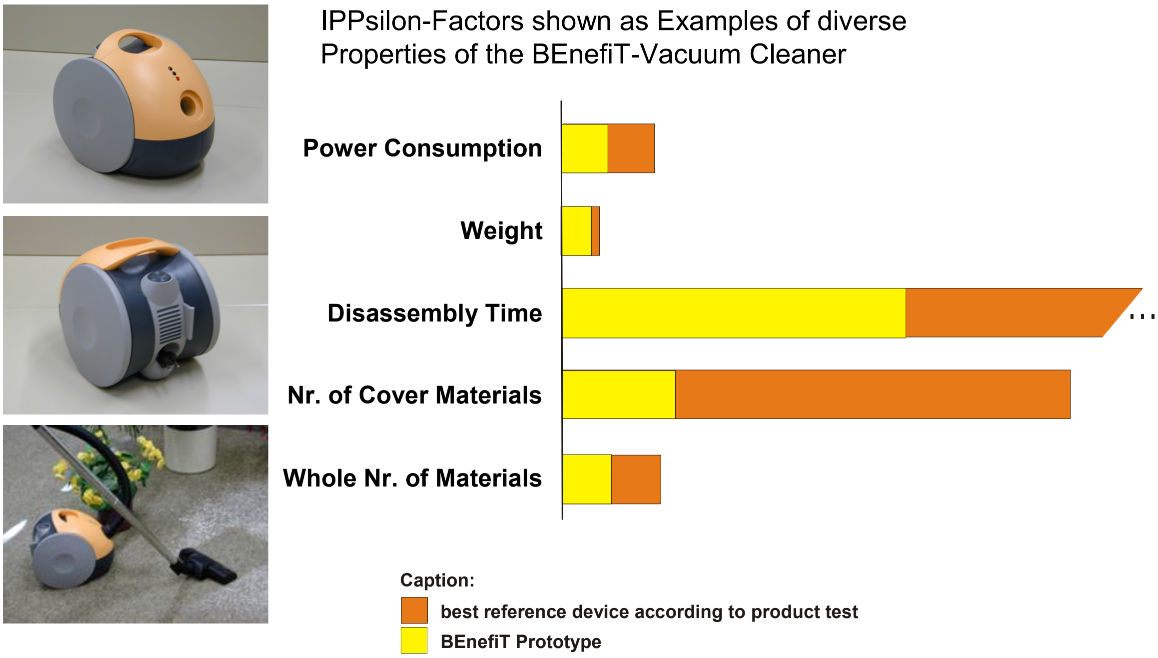



Figure 8: Features of the prototype

# 5 Product innovation centre

The idea and the working in an interdisciplinary network have been successful. Furthermore the methodical approach in addition with the use of IT-based tools enabled the team to work in a sense of predictive engineering and following the philosophy of Integrated Product Development/Integrated Product Policy.

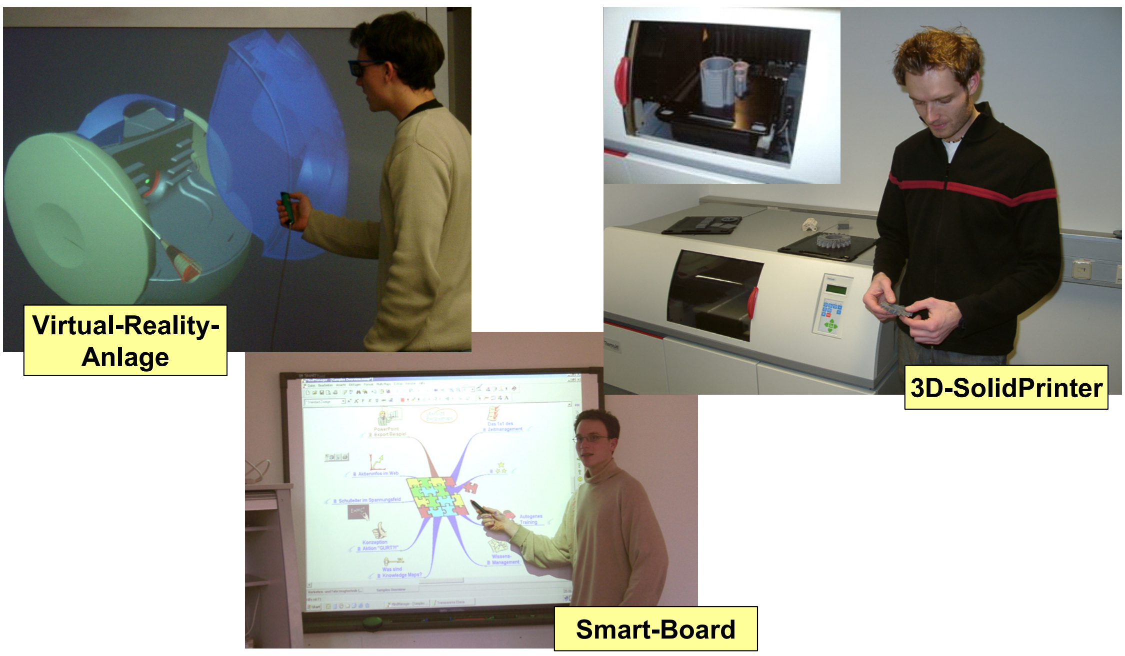



Figure 9: BEnefiT-product innovation centre

Therefore this approach should be realized in other tasks and product lines. The technical equipment for solving future problems could be improved and realized in a BEnefiT product innovation centre. A rapid prototyping machine (3D-Printer) and a Smartboard for interdisciplinary team work together with a virtual reality system are now an excellent technical base for further projects in the future.

# 6 Conclusion and outlook

By developing and realizing a prototype of a vacuum cleaner we could show that the philosophy and the procedure of Integrated Product Development and Integrated Product Policy are powerful enough for innovation and for improvements even in the field of well developed products. Working in an interdisciplinary team combined with a methodical and IT-tool based approach allows us to create successful solutions for sustainable products. The procedure as well as the used methods and tools are concentrated in a guide which is available for all enterprises.

The interdisciplinary network should not be seen as a static system but as an approach which must be dynamic and therefore be adapted to the actual tasks. For the future we plan to use this approach in a field of products with extremely short lifetime in the market: mobile telephones.

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