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AN APPROACH TO COMPARE PRODUCT DEVELOPMENT METHODS

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ABSTRACT

The manifold activities of product development are the substantial activities within a company, as these, due to their innovation character, are the foundation of the company's success. Many development theories and methods were and have been developed during the last fifty years all over the world. Their main reason is to foster a successful product development and to gain an improved knowledge on the insight of it, i.e. not only on its results, but as well e.g. on drivers, purposes, activities, processes, procedures, methods, and tools. In order to support a better understanding of the respective rationale of product development methods, to allow an easier comparison of different methods, and to show further research opportunities, research on criteria to compare these methods has been conducted with the goal to create a comparison framework. The criteria have been grouped so far into basic concepts, integration of different domains, procedure style, adaptability and flexibility, predictability of results, and transfer. After the presentation of the criteria groups and selected product development methods, a comparison of these methods is described.

Keywords: Product development method, method rationale, comparison criteria

1 INTRODUCTION

Product development[1], which plays a key role in today's enterprises, covers at least marketing and product planning, styling, development, design, and the planning of appropriate production processes. It can be described as the area, in which the global and complete product model is developed and documented from the first idea (or market needs) and its appropriate requirements to the complete documentation of all the following activities within the life cycle of a product. Product development usually happens in close cooperation of its stakeholders, whereby all stakeholders are of the same importance. It was already reported in 1970 that, in accordance with the Pareto principle [38], up to 85% of the later product costs are specified within product development [1], which underlines the enormous importance and great responsibility of people working in product development.

Product development can deal either with the development of a new product (either "from scratch" without role model or by variation of existing solutions) or with the adaptation of an existing one. It is usually driven and highly constrained by internal and external influences, like orders, requirements of external and internal customers, market gaps, spontaneous innovative ideas, or enterprise guidelines, which define the product characteristics and/or the tasks during product planning. All these put up, shape, and continuously change the solution space for the given problem. All these are dynamic, i.e. can vary along the development process, thus making product development difficult to predict. Errors during the early phases of product development may lead to re-design and high additional costs in later phases (e.g. production or service) [2] [3] [4].

Research on theories and methods to describe and to support product development (or at least parts of it) has a long tradition, Figure 1. Research results cover well-known paradigmatic approaches and models. They are partly built upon experiences from practice, and a lot of them haven't changed much during the last 20 to 30 years. They describe the design process (e.g. [5] [6] [7]) or the product devel-

1 Within literature, the term "product development" is often used and described in the same meaning as the term "design" or to be equal with "design". However, product development (sometimes also called "Engineering") is the substantial part of the product life cycle, whereas design is a sub-process of product development having its main focus on realizing the fulfilment of the functional requirements.

opment process (e.g. [8] [9] [10] [11]) in form of appropriate models. Some of these were defined as standards or guidelines due to the high degree of maturity of the rules, models, and regulations they contain (like the 22xx guideline series of the VDI, the German Association of Engineers, e.g. [12] [13] [14] [15] [16] [17]).

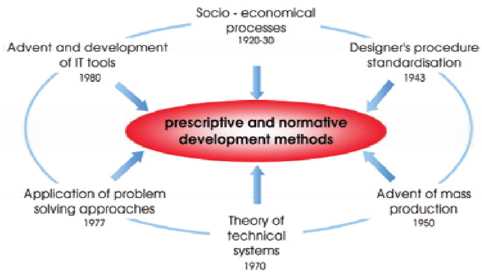

Figure 1. Development method origins

However (and as reported e.g. in [18]), one can state a certain "inflation" of such kind of methods that may require consolidation. Steps before consolidation are awareness (as also reported in [18]) and comparison.

2 COMPARISON CRITERIA

Comparing different product development methods or design methods has been always of interest (e.g. [39] [40] [41]). The focus on the research described here is to find (a presumably small number of) independent criteria that allow capturing the rationale and the performance of a method. Here, "performance" means the degree of fulfillment of the criteria described later in this chapter. The expected small number of independent criteria shall allow a meaningful comparison with limited effort. The criteria shall form a comparison framework, which will provide appropriate comparison procedure patterns, and which also may lead to a certain classification and structuring of the compared methods (as proposed e.g. in [35] [42]). Further motivation results from the following questions:

- When researching on product development methods one would like to compare one's own results and progress with other research results, both for looking for research co-operation and in order of benchmarking the own results. It is also worthwhile (e.g. when discussing new research topics) to get early information of further research opportunities within a particular research area.
- When working on new curricula for different grades and their respective contents a comparison may help to identify those methods that offer appropriate and sufficient content in a both plausible and suitably structured way, which can be educated both by teaching and by self-learning. In conjunction with the motivation mentioned above, such a comparison may also help when a readjustment of the subjects taught is needed.
- When transferring research results on product development into practice, the comparison, on the one hand, could indicate, which of these results could be the most appropriate for a given situation in practice. On the other hand (in analogy to the first motivation), it could help to detect research necessities for a given situation.

After the presentation of selected criteria and a short description of selected product development methods, a comparison of these methods is described in this paper.

2.1 Criteria groups

For the present within this research, the criteria have been structured into (1) basic concepts, (2) integration of different domains, (3) procedure style, (4) adaptability and flexibility, (5) predictability of results, and (6) transfer, Figure 2.

Figure 2. Criteria structure

2.1.1 Basic concepts

Basic concepts serve as an information base and thus cover the characteristics of the method. Among these is the foundation, i.e. whether the method has a (solely) mathematical foundation or has been derived from empirical studies (as a "distillation" and refinement of investigated approaches and proceedings from practice) and all kind of steps in-between these two extremes. Of interest is also the fact whether the foundation is structured, i.e. it has a certain structure (sequential, hierarchical, parallel, or relational etc.) or is meshed, object-oriented, or is disordered, multidimensional, or chaotic. Does the method support or foster innovation by enabling the "crossing of the borders" of domains included, e.g. by supporting analogies? A further aspect is the complexity level of the method (in a sense that a complex system is comprised of a large number of entities that show a high level of non-linear activities [19]). Does it only describe the development of simple products or can it handle development tasks of (almost) any complexity? If suitable for complex tasks, how does it decompose a given (complex) problem into smaller elements that can be handled easier without loosing coherency? Is it a toolbox or an integrated concept? How easy are the access and the filling of the underlying knowledge base? When looking on computer support, does the method incorporate approaches that are only possible due to this support (e.g. all aspects of simulation, calculation, virtual realities, linked with ongoing prediction and evaluation approaches) and is it laid out to incorporate further developments?

2.1.2 Integration of different domains

Integration means at first whether the method is able to consolidate several application areas (e.g., besides mechanical engineering also electrical and electronic engineering, software engineering, and, as a consequence, mechatronics). Does it take into account economical influences from business science and findings from other areas (e.g. biology, cognition ergonomics, and working psychology, etc.)? Can it support as one single method people from different domains, with different knowledge profiles, to working together or (if appropriate) on their own? Does it support communication? What are the goals of the development method and how are they structured? Do these goals go beyond the fulfillment of functional requirements? Do the goals cover in an equivalent way shape and appearance ("product language"), intuitive handling (ergonomics), sustainability, producibility and serviceability, and appropriate price-performance ratio? What is the working result (this should be any kind of product, not limited to a certain branch, but including physical products, software, and services of any kind)?

2.1.3 Procedure style

Procedure style deals with the underlying process model(s) of the development method. Does the application of the method force the engineer to follow a predetermined set of activities that are difficult to change, i.e. the phase models and action schemes are linear? Does the method provide a choice of suitable action possibilities according to the actual situation (context sensitivity) in order to allow an opportunistic and a flexible though systematic proceeding? Does it support the parallelization of activities (and, if so, to what degree)?

2.1.4 Adaptability and flexibility

Adaptability and flexibility means whether the method allows an additional / a continuous change of specifications of the environment in which the procedure was started. Such changes apply to external and internal requirements, preconditions, starting conditions, boundary conditions, and constraints, because these can change during proceeding time, driven by external influences, thus can be adapted to new situations. Does the method foresee and allow easy iterations, rebounds, and loops? Do a comparison and evaluation of the actual results accompany this in order to provide the engineer a continuous feedback of the appropriateness of his actual measures?

2.1.5 Predictability of results

Does the method anticipate results, i.e. is it based on the paradigm that a complete description of requirements and boundary conditions will lead (at the very end) to exactly one solution (the so-called "funnel approach")? Or does it provide a set of equivalent, but not similar solutions, thus allowing the developer to select in due time the most appropriate solution for his problem from this set, even if specifications or other conditions were changed along the development?

2.1.6 Transfer

This criterion covers the aptitude to transfer the rationale and the knowledge of the method to other people (teachability) and to any kind of products (generality) as well as the adaptability of the method to a given industrial problem, accompanied by the respective outcomes (practicability).

- Teachability: Is the method well structured and are its contents consecutive, consistent, and coordinated? What kind of scientific and practical pre-knowledge is necessary? Can the method be taught by a step-by-step approach or is it necessary to teach a broad base of (rather theoretical) facts and procedures first before an understanding of the method is possible? Can parts of it acquired by self-learning (which covers both the acquisition of facts from external sources and an accompanying project work)? How difficult is the adaptation of the theoretical base for solving a given problem?
- Generality: Can the method be applied without significant changes to the development of any kind of products, i.e. physical products, software products, consultancy and service, and of combinations of these (e.g. product service systems [43])?
- Practicability: Is it generally possible to transfer and to apply this method in practice? Has it been applied in industry? If so, in which industries (branches)? To what kind of products in question of type, size, complexity? What kinds of experiences have been reported? Does it need a special environment (in question of e.g. of organization structure, internal operations structuring, cooperation schemes, and IT support) or can it be applied in any kind of situations? Which are the preconditions and constraints for a successful transfer? Will the method create benefits (not necessarily monetary value) and what kind of benefits?

2.2 Selected product development methods

Within the scope of this paper it is not possible to provide information on all existing or relevant product development methods. The methods presented further in this chapter are those that are actually investigated at the chair of the author, and this selection doesn't claim to be complete. However, the selected methods show an interesting variety in describing and supporting product development, and they range from "classical" to "modern" approaches. The following methods will be presented in a short form: VDI 22xx guideline series, Integrated Product Development, TRIZ, Universal Design Theory, Characteristics-Properties Modeling / Property-Driven Development, Dynamic Product Development, and the Autogenetic Design Theory.

2.2.1 VDI 22xx guideline series

The VDI guideline series 22xx describe an extensive model of product development with a certain focus on design activities. The rather "classic" guidelines are based on the respective design theories developed mainly in Germany by PAHL and BEITZ [7], HUBKA [20], KOLLER [21], and ROTH [22]. Newer guidelines, e.g. the 2206 guideline, propose an advanced approach, in which the main parts of the design process described mainly in the guidelines 2221 and 2222 are re-oriented in accordance to the requirements of mechatronics. With its potential multiple and parallel flow paths, its underlying "V"

model provides a first step away from a predominantly sequential approach. The disadvantage of this model is that essential work steps are handled separately and only the next step integrates the partial models into an overall solution. Only in this step a review of the interaction is done.
The VDI guidelines mainly aim at supplying methodical and branch-independent bases for developing and designing technical systems and products for a wide range of applications. They provide a systematic and planned procedure for solving technical problems, although the sequence of the work procedures is quite rigid and inflexible. The underlying product development model is based on a system-oriented procedural model, where the procedure steps in the life phases of a technical system recur (planning, conceptualization, designing, and detailing). Simultaneously, an evolution of the technical system from the abstract to the concrete takes place.
The general phase model approach of the VDI 22xx guideline series allows the processing of a variety of development tasks, for example in the development of software or services. The designer is supported in the first two stages during his search for principle solutions. In the last two phases, the concept is more and more restricted (in the meaning of a "funnel model"), until the desired solution is found. In order to optimize the possible solutions, single steps can be repeated, and it is also possible to return to previous steps.

2.2.2 Integrated Product Development (IPD)

IPD as first proposed by OLSSON [23] and further developed among others by ANDREASEN and HEIN [8], EHRLENSPIEL [9], and BURCHARDT [24] offers phase-based approaches of product development, such as demand analysis (identifying and specifying the requirements), drafting of a concept, detailing, preparation, and implementation.
The product development process is described as a cyclic activity with iterations and recursions. As a result of the diversity of options and alternatives in designing the product (that grows with the degree of detail), the best solution is selected and implemented. The sequence of the individual steps is predefined and the individual phases of IPD are sequentially processed. The solution search follows the TOTE pattern (Test-Operate-Test-Exit), i.e. an automatic control loop-like procedure where the loop is passed through until an adequate solution is found. Occurring sub-problems, when working with this methodology, lead to the re-start of the respective sub cycle.
Newer research treats IPD as a human-centered procedure for developing competitive products or services of high quality, within a reasonable amount of time, and with an excellent price-performance ratio. Integration in such an environment is achieved in multiple dimensions:

- Actors: People from different departments with different skill profiles, who are involved in the product life cycle, work together and take decisions at the earliest possible time.
- Results: Any kind of product can be developed. The approach isn't limited to a certain branch, but can cover physical products, software, and services of any kind. Development goals cover equivalently function fulfillment, form and appearance ("product language"), intuitive handling (ergonomics), manufacturability, sustainability, and efficiency.
- Organization and behavior: Dynamic, not static because of the dynamic environment in which IPD happens. Components of this environment are dynamically changing requirements, constraints, and starting and boundary conditions ("running targets"). The work is performed in parallel processes wherever appropriate.
- Supportive methods: Holistic and multidisciplinary methods. The most appropriate methods for a given task are applied. Methods are provided context sensitive.
- Supporting technology: Both manual and computer-supported tools with minimized and sustainable use of production factors and resources, covering generation tools as well as tools for prediction, simulation, and evaluation.

2.2.3 TRIZ

Three statements form the base of TRIZ developed by ALTSCHULLER [25]: (1) Most inventions are based on a relatively small number of general solution principles. (2) The central element of many innovations is the contradiction. (3) The evolution of technical systems follows certain basic rules. These statements are based on the analysis of over 200,000 patents. It was found that only every fifth patent is supposed to be a real innovation. The remaining patents were (more or less) recombinations

of already known technical systems. From this data base 40 active principles or partial solutions were identified for the development of innovative solutions.
The approach of TRIZ is subdivided into four steps:

- Description of the design problem.
- Abstraction of the described design problem (e.g. reduce on a physical problem). Thereby, the design problem is reduced on a conflict of two opposing parameters. For that, a list of 39 physical and technical parameters is used.
- Search for known solutions for the abstracted problem, by applying the 40 basic active principles. TRIZ uses a so-called opposition matrix from which, depending on the selected parameters, appropriate suggested solutions were chosen.
- Back-transformation of abstract problem to solve the original design problem.

Each new solution is generated from the pool of 40 basic partial solutions or active principles. Thus, content and quality of that pool limit the solution space and the achievable solution quality. Additionally, there is always the danger that the maximum level of innovation cannot be reached and that the new solution is not really new. Solutions generated with TRIZ are always only in the concept stage and need to be detailed.
Abstraction of the problem plays an important role in the application of TRIZ. Often, multiple choices of the 39 parameters are possible. Depending on the chosen parameters, different solution suggestions will arise. Another difficulties can be found at design problems, where the simultaneous optimization of more than two parameters is required. Because TRIZ is strictly limited on two parameters, design problems with more parameters cannot be solved. The underlying parameters and partial solutions can essentially only be applied on product development problems. A universal use in other areas isn't possible [26].

2.2.4 Universal Design Theory (UDT)

GRABOWSKI, RUDE, and GREIN developed UDT [27], which aims to be a general theory for solving engineering problems, were knowledge from other fields (not only engineering) is incorporated. In order to get the widest knowledge base possible, an interdisciplinary co-operation of all stakeholders in product development and adjacent areas is the goal. However, this co-operation is often difficult because different approaches, methods, and theories are used in the different disciplines and thus descriptions and expressions can differ from each other. At first, UDT provides a general framework for interdisciplinary co-operation. By considering the similarities of various disciplines, general statements on the description of products are offered. Possible difficulties arise from the attempt of UDT to provide simultaneously both universality and practicability.
Basis for a successful product development is a complete and accurate description of all requirements for the product. To ensure practical applicability despite the universal approach, the core of UDT can be used to create any product. This core is enhanced with concrete information from the respective disciplines and leads to the desired solution.
UDT applies three key axioms to describe the product development process:

- The product development process can be described in different levels of abstraction. The number of levels, however, is limited.
- The number of elements available to describe at each level of abstraction at a certain time is limited, but it can be changed, e.g. through research.
- The number of transitions between the levels of abstraction is also limited.

Based on these axioms, the hypothesis is proposed that the creation of a new product can always be realized by combining existing elements. The number of possible combinations is clearly defined by the requirements.
UDT can be used in the development of a wide range of products. However, the development of a new product is performed through a combination of already known basic elements only. Because of this, developments cannot extent the range of currently known elements beyond. An innovation jump doesn't seem to be possible. In [27] it is also assumed that a precise (and complete) solution description is able to produce exactly one single solution, which meets all the requirements (similar to the funnel model). Whether this is always true (even in complex environments) hasn't been discussed yet.

2.2.5 *Characteristics-Properties Modeling / Property-Driven Development (CPM/PDD)*

WEBER has developed CPM/PDD since the early 2000. In this theory, CPM provides the methodology and the description of the product model, whereas PDD describes the procedure within the product development process [28] [29].

The core of the theory is the differentiation between properties and characteristics of products. Properties of a product are e.g. weight, power, and functions. Properties describe the (required) behavior of the product and cannot directly be influenced by the designer. Characteristics of a product are e.g. dimensions and materials. Characteristics describe the shape and appearance of a product and can be influenced by the designer directly.

Within CPM/PDD, the connection between characteristics and properties is realized through analysis and synthesis. Synthesis is the main component in the product development process. CPM uses external conditions and dependencies, because synthesis and analysis cannot be executed completely unlimited. Through external conditions, the solution space for the solutions is defined. Dependencies between the single product characteristics lead to further restrictions of the solution space.

This model of product description is the basis for PDD, which tries to minimize the gap between nominal and actual product characteristics through alternating synthesis and analysis.

CPM/PDD is a general approach for the description of the product development process, which focus is on the relationship between product features and product properties. The loop presented in CPM/PDD is an iterative optimization process, similar to the development process of the designer. The critical point of the loop is the conclusion step, which decides for the parameters to be adjusted. The decisions taken here are decisive for the quality of the resulting product. The problem in this step is the assignment of the right product properties to a particular product characteristic, because this assignment is not always clear and often characterized by conflicting objectives.

2.2.6 *Dynamic Product Development (DPD)*

With the aim to heavily reduce time-to-market when developing new products, OTTOSSON has developed DPD [11] [30] based on the following observations:

- Product development is complex as the development situation changes all the time in a way by external and internal influences that is difficult or impossible to plan for.
- Chaotic situations tend to occur with shorter intervals as a consequence of technology development, globalization, information, and communication development.

Dynamic behavior is characterized by a high degree of flexibility, rough long term planning, detailed short time planning, decentralized decision making, and informal fast follow up systems. Traditional behavior is characterized by a low degree of flexibility, centralized decision making, detailed long term planning, formal one-dimensional follow up systems, and high system transparency.

DPD implies a dynamic, responsible and sustainable procedure to develop products of high quality. The dynamic results from the decentralization, combined with rapid feedback on many "small" decisions and commitments towards the development objective, which is not stable, but changing itself due to changed requirements, changed resources, new technologies etc. DPD tries to combine knowledge from different domains of product life, i.e. marketing, development, production, distribution, usage, customer service and the return of a product. For the solution finding process initially intuitive methods were applied, which run under the slogans BAD - PAD – MAD[2]. By using DPD short throughput times, high user satisfaction, and a positive work climate can be achieved [31].

One important conclusion for DPD is that it is rather a waste of time to plan in detail more than for one week, give or take a few days. Instead a clear vision, rough long-term plans, and detailed short-term plans are used. This as, according to DPD, complex situations are difficult to foresee and simulate, which is also why real/verifying-tests are always needed to make good products.

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2 BAD: Brain-aided Design: Getting all requirements, collecting all necessary information, defining the support needed, and preparing the work. PAD: Pencil-aided Design: Sketching different solution variants in order to find the best solution possible. MAD: Model-aided Design: Creation of (partly rough) prototypes, checking the styling and the haptics of a product, and performing optimisation cycles [30].

2.2.7 Autogenetic Design Theory (ADT)

The purpose of ADT is to view the genesis of a product during the design process as an analogy to the (technical) evolution of living creatures, to describe the design process as a continuous development process of technique and technology, and, by this, to provide a better understanding of the nature of the design process. In contrast to Bionics, where *results of biological evolution* are transferred to product development, it is the key element of ADT to transfer *terms and procedures of biological evolution* theory into design theory.

A lot of product development methods describe product development as a phase-wise process. In each phase, different alternatives of a solution are searched from existing solutions, developed, varied, combined, compared, and evaluated. These alternatives compete with each other. Alternatives that fulfil the requirements sufficiently are selected for further treatment, combination, and development. These activities

- lead to an increase of complexity of the regarded solution (described by so-called "complexity levels"), whereby the increase can be horizontal (i.e. along the time line) or be vertical (i.e. increasing the concreteness of the solution by respective development processes). This procedure is called *Autogenesis* within the Evolution Theory [32].
- can be found in a similar pattern in all "classical" phases of product development and on all levels of complexity. Therefore, they are self-similar and may be described as a general scheme.
- can also be found as typical procedures within biological evolution.

Evolution means gradual development, permanent adaptation, and optimization towards an aim that may also change itself during the evolution. Both the development of a new product (new or original design) or the change of an existing product (adaptation design) can be described from the evolutionary view as a continuous optimization of a basic solution by observing starting conditions, boundary conditions, and constraints (which may evolve themselves, too). The description and the modeling of all procedures within the design process are furthermore components of ADT [33].

Different research activities show that the genesis of solutions follows in all phases and organizational levels the same procedure (comparable with the TOTE-scheme [9]). The scheme of the genesis of a solution is a self-similar procedure. This self-similar procedure exists in all phases of the product development process and the emerging product [34].

One of the main differences to existing development methods is the effect of the changing solution area within ADT. External events (e.g. a change of requirements) lead not only to changed requirements and tasks, but also to changing conditions and constraints, which change or add possibilities, or may close existing possibilities for the evolution. In order to consider all actual aspects, it is necessary to reshape the solution area, and to start the search in the whole re-defined solution area.

3 COMPARISON OF THE SELECTED DEVELOPMENT METHODS

The results of the comparison of the product development methods described in chapter 2.2 by using the criteria described in chapter 2.1are shown in Table 1, which displays the highest level of the comparison. There are further levels with more details. The highest level is focussed on qualitative assessment in order to provide a useful overview.

Due to the comparison of characteristics that can't be always evaluated with one assessment standard, different evaluation increments were applied:

- A criterion is met (Y=yes) or isn't met (N=no). In the case where the completion can't be (yet) decided from the description of the respective method, the criterion is marked with P (=plurivalent).
- The degree of fulfillment of a criterion is marked with H (=high), M (=medium), or L (=low).
- The quality of fulfillment is marked with five qualitative grades: Very good (++), good (+), fair (0), bad (–), very bad (– –).
- No preference (=n.p.) is given when a certain criterion doesn't apply or when the respective method isn't influenced by this criterion. For example, as TRIZ predominantly is an automated product development method that provides solutions based on active principles, physical and technical parameters, and basic partial solutions without involvement of human work, the criterion "consideration of social sciences" doesn't apply.

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Table 1: Comparison of the selected product development methods

	VDI	IPD	TRIZ	UDT	DPD	CPM	ADT
General applicability	+	++	++	++	++	+	++
Innovation enabling	0	+	0	0	+	0	++
Complexity of the method	L	L	M	M	L	M	M
Complexity of the supported products	M	H	M	M	H	M	H
Exploitation of computer support	M	H	H	M	M	M	H
Integration of different domains	+	+	++	++	++	+	++
Applicable to different kind of products	+	++	+	+	++	+	++
Balancing of different product goals	–	++	–	+	++	+	++
Analogies to nature	N	N	N	N	N	N	Y
Inclusion of economical influences	–	++	0	0	++	+	+
Consideration of social sciences	–	++	n.p.	0	++	N	n.p.
Support of communication	0	++	n.p.	P	++	0	n.p.
Support of single work	++	+	n.p.	+	+	+	n.p.
Support of teamwork	0	++	n.p.	+	++	0	n.p.
Systematic and predetermined procedures	Y	N	Y	Y	N	Y	N
Opportunistic course of action	N	Y	n.p.	P	Y	P	Y
Parallelization of activities	–	++	n.p.	P	++	+	++
Dynamic reaction to changes of conditions	–	+	–	P	++	0	++
Ongoing comparison and evaluation of actual results	0	+	P	P	+	–	++
Continuous feedback	–	++	N	P	++	–	++
Anticipation of results	Y	N	N	Y	N	N	N
Several equivalent, but not similar solutions	N	Y	Y	N	Y	P	Y
Teachability	++	++	–	–	++	+	+
Generality	+	++	0	++	++	+	+
Practicability	0	++	+	–	++	+	+

Comparisons like the one in Table 1 offer various conclusion possibilities, e.g.:

- Within research, if one is working on a certain development method, the comparison could provide further research opportunities. For example, investigating the ability to react dynamically to changing environments and conditions would be such an opportunity, as some of the compared methods don't show this ability.
- If one has to teach beginners in the basics of product development, a development method with clear and predictable structure that can be taught easily would be the most appropriate choice. In this case, one could select from the methods that form the base of the VDI 22xx guideline series, e.g. Engineering Design from PAHL and BEITZ [7].
- In industry, a company producing consumer goods with short stock turn over time, with a focus on styling and good price-performance ratio (e.g. communication products, optical products, small personal appliances, etc.), could apply best IPD or DPD.
- A company producing complex special purpose machinery, with made-to-order production to a broad variety of industrial customers, and with permanently changing requirements, could apply either ADT or a combination from IPD and TRIZ.

4 SUMMARY AND OUTLOOK

The main focus of this paper was to present an ongoing research on criteria and approaches that allow a comparison of product development methods. Such a comparison should support a better understanding of the respective rationale and distinctive characteristics of the regarded development methods. The development goal is a comparison framework.

The actual research (besides the investigation of further comparison criteria and their relations) is focussing on the following: Searching for more summarizing criteria, which allow the comparison of

several characteristics with enough detail within only one comparison activity (according to the simplified benchmark approach described in [35]), building up the comparison framework and defining the comparison procedure patterns, and, in order to evaluate comparison results from several points of view, the incorporation and adaptation of the industry-proven Benefit Asset Pricing Model approach (BAPM) [36] [37]. BAPM calculates the (not necessarily monetary) value of a comparison outcome portfolio with corresponding procedures and methods from the money market.
The combination of these activities will provide a fast but thorough comparison (and, possibly in the long run, classification) of product development methods.

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