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A LANDSCAPE OF METHODS – A PRACTICAL APPROACH TO SUPPORT METHOD USE IN INDUSTRY

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1. Introduction

Design engineers in practise have to deal within the so-called magic triangle between quality, costs and time to market. Often products are becoming more complex, for instance with the incorporation of mechatronic systems, and interdisciplinary teamwork is required for product development. Additional new requirements - the European Unions End of Life Vehicles (ELV) directive for instance - can be high on the agenda.
To consider all these demands for product development is sometimes very challenging and therefore the use of adequate design methods, methodologies and tools can provide powerful help.
But for practitioners in industry it is hardly possible to keep an overview of the numerous existing methods. Every year new methods appear and new buzzwords (e.g. Design for Six Sigma) come up. Several detailed and well-established collections and descriptions of methods already exist [Ehrlenspiel 2003, MAP, Daenzer and Huber 1997], but an easy-to-use approach to get a holistic overview is missing so far.

2. Objectives

The objective of the work presented in this paper is to create a so-called *Landscape of Methods (LoM)*. Together with a short and concise classification of every included method this should enable a quick overview without the necessity of being familiar with the regarded methods. An additional objective is to develop a support system to identify appropriate methods for a given task.
The whole approach should enable to highlight specific ways through this Landscape of Methods.

3. Methods

Literature search defined the state-of-the-art [see for instance Ehrlenspiel 2003, MAP, Daenzer and Huber 1997, Lindemann 2003]. This approved that an overview without reading a lot of product descriptions is not available and the selection of methods is only supported with clustering methods into certain categories. This research showed also that methods for Design for Environment (DfE) are hardly considered in standard product development literature. But with new legislation - the EU's Waste Electric and Electronic Equipment (WEEE) directive for instance - this task becomes more and more important. And also for product innovation a DfE task can be the trigger [see Strasser and Wimmer 2003].
We included methods for *quality*, *costs*, *development time* and appropriate *DfE* methods in the preselection of methods to define the method-pool for the LoM.

The basis for the LoM builds a model of the product development process (Figure 1) with four stages (clarification of the task, concept design, embodiment design, detail design). In every stage a micro cycle (situation analysis, target specification, idea generation, evaluation) to solve a problem can be deployed according to the Systems Engineering [Daenzer and Huber 1997] approach (Figure 2). In the early stages of product development the focus will be more on the steps *situation analysis* and *target specification*, in the later stages the focus will be more on the steps *idea generation* and *evaluation*. This model should provide high adaptability to real situations in industry.

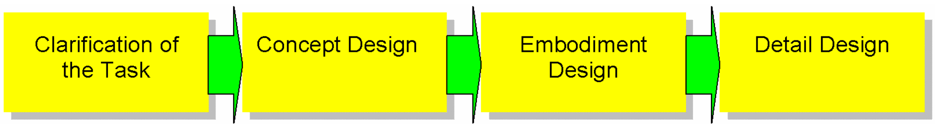

Figure 1. Product development process model related to the LoM

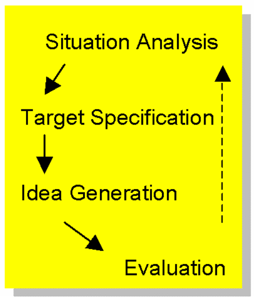

Figure 2. Problem solving cycle

3.1 Landscape of Methods (LoM)

For the draft of the LoM appropriate methods were assigned matching steps from the problem solving cycle. Methodologies like TRIZ [Terninko et al 1998] are therefore divided into their constituent methods (Inventive Principles, The Ideal Design, Patterns of Evolution, …). For instance the TRIZ Inventive Principles are assigned to the step *idea generation*. The TRIZ Patterns of Evolution are assigned to the step *situation analysis*.

Some methods do not fit to one of the four steps. Additional categories for universal methods (e.g. Black-Box Method) and methods for workshops are therefore added. For helping to reduce the time for product development also a category for methods for project management is included.

To keep the overview the methods are arranged to so-called basic modules. The module *Intuition* for instance contains Brainstorming, Brainwriting among other methods.

Graphically the LoM is realised as a Mind Map using a commercially available mind mapping software (see Figure 3).

With this software it is easily possible to navigate through the LoM by switching on or off the different modules, which means to show or hide the underlying methods.

Additionally it is possible to draw in suitable method combinations. For instance when using the TRIZ Inventive Principles for idea generation it could be very helpful to combine this with the use of a *Collection of Effects and Phenomena* as well as with a Brainstorming Session for idea stimulation in a very effective way. In Figure 3 this combination is indicated on the left side using arrows with continuous line.

Also sequences to use methods can be indicated. For instance after using a Gantt Chart for project management and realising that development time is too long due to extensive product tests the use of a Virtual- or Rapid-Prototyping Method can speed up the process. In Figure 3 this sequence is indicated on the right side using arrows with dashed line.

To be able to understand the purpose and nature of the different methods in a quick way a classification form was developed.

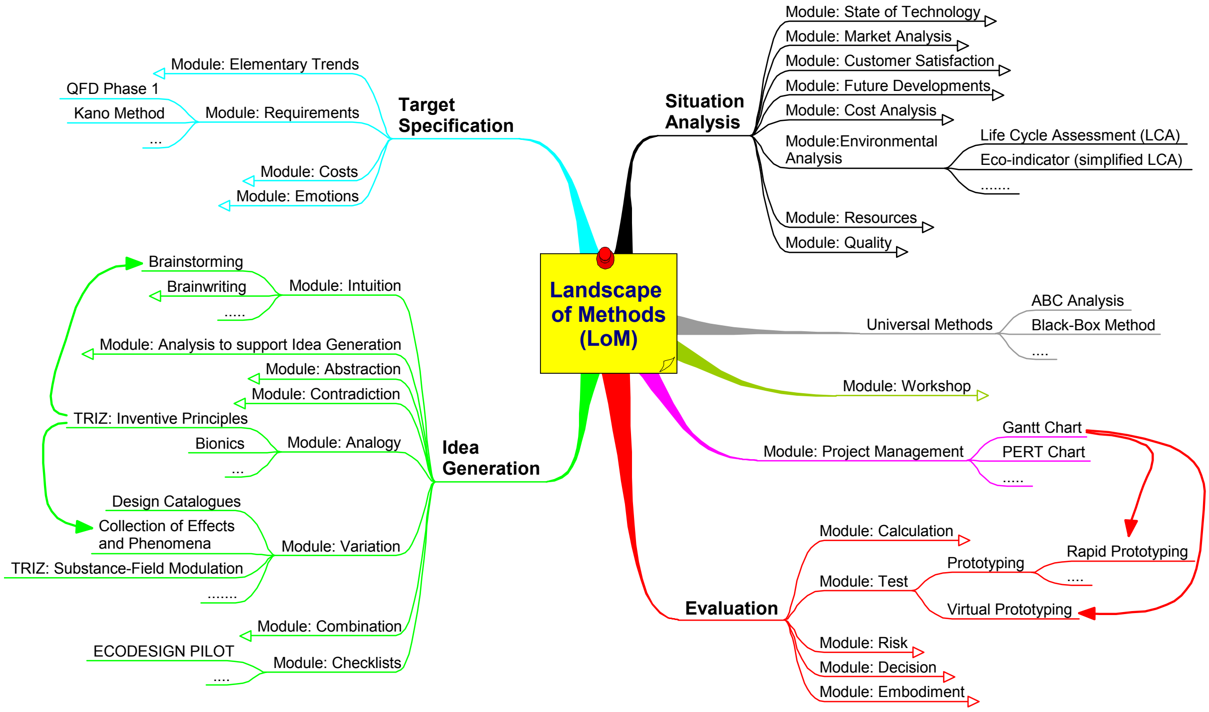

Figure 3. A Landscape of Methods (LoM) for comprehensive overview

3.2 Classification form

The classification form contains the following items on one page (maximum 2 pages for complex methods):

- Name of the method – includes if necessary different used notations (e.g. Ishikawa-Diagramm = Fishbone-Diagram)
- A short description with about 100 words
- The primary purposes of the method (e.g. for QFD Phase 1 one of the primary purposes is to transfer sometimes rather "fuzzy" formulated customer requirements into related technical parameters)
- Secondary purposes of the method
- Information if teamwork is explicit necessary or not to perform the method
- Information if the method is suitable for rather complex tasks or not
- Information if the use of the method will lead to a rather adaptive design, which means implementation risk will be low
- Information if the use of the method will rather lead to an innovative design (e.g. using the TRIZ Inventive Principles can bring up totally new ideas but probably with higher implementation risk)
- Information about learning effort, manpower needed and expenditure of time
- Information if it is necessary or not to use specific software
- Information if combination with other methods will create synergies
- Hints for application and adaption gathered from practical experience
- Information about specific literature

Very important are the included practical hints for application and adaption because this can support the use of a method even if the conditions are unfavourable (e.g. no time for learning the method). For instance to identify appropriate TRIZ Inventive Principles the classical TRIZ approach uses the TRIZ Contradiction Table. But to work with this Contradiction Table in a proper way needs some training effort and experience. But it is also possible to work with the Inventive Principles alone, with minimum learning effort, when having good examples of explanation.

3.3 Questionnaire to select methods

The classification of all the methods from the LoM builds the basis for developing a questionnaire to select methods. The selection will be performed in a two-step process. The first step will assign task specific questions to related modules. The second step will then lead to the matching method. Figure 4 shows how the first selection step is performed. The matrix shows how a Module with its included methods can contribute to answer a specific question (= solve a task). A strong contribution is indicated with 9, an average contribution is indicated with 3, a weak contribution is indicated with 1 and no contribution equals 0 (= blank field). If a question is already answered (or not relevant) the answer factor obtains the value 0 (= blank field), if not, the factor is 1 (see the highlighted column in Figure 4). The priority of each Module can be calculated by multiplying for each column the assigned contribution factor (9, 3, 1 or 0) with the answering factor (0 or 1) of each row and summing up.

The indicator in the first column shows if a question is mainly dedicated for a task to develop a new product (Indicator N), or to improve Quality (Indicator Q), or to reduce costs (Indicator C), or to reduce development time (Indicator T). For a universal question the indicator is U. The indicator should help to go through the questionnaire in a quicker way, first concentrating on the primary task.

Indicator	Modules / Contribution of a Module for answering a question: strong contribution = 9, average contribution = 3, weak contribution = 1, no contribution = 0 / Questions	Answer: no = 1, yes = 0, not relevant = 0	Module: State of Technology	Module: Market Analysis	Module: Customer Satisfaction	Module: Future Developments	...	Module: Environmental Analysis	Module: Requirements	Module: Costs	...	Module: Intuition	Module: Analysis to support Idea Generation	...	Module: Analogy	Module: Variation	Module: Combination	Module: Risk	Module: Project Management	...
N	Are potential technologies well-known?	1	9	1		1														
N	Are potential markets already identified?			9	1	3														
N	Is the substantial data of the market well-known?			9																
Q	Are possible future changes of the customers requirements well-known?	1		1	1	9														
	...																			
E	Is the environment impact for the entire product life cycle well-known?	1						9												
Q	Are the technical requirements present in a clear, precise and complete way?	1							9											
C	Were special measures already considered for cost reduction?									9										
U	Are measures already considered to increase the innovation degree?					1						9			3					
T	Are similar technical systems sufficiently well-known, in order to minimize the own efforts?		3	3									9							
U	Were special measures already considered for the evasion of valid patents?															3	9			
Q	Are endangerments considered and with it connected risks explicitly well-known?																	9		
T	Is the product development procedure already optimized, in order to save development time?																		9	
	...																			
	priority (absolut)		9	2	1	10	0	9	9	0	0	0	0	0	0	0	0	0	0	0
	priority (relative %)		23	5	2,5	25	0	23	23	0	0	0	0	0	0	0	0	0	0	0

Indicator: N= New Product, Q= Quality, C= Costs, T= Time, E= Environment, U= Universal

Figure 4. The first step of the selection process assigns task specific questions to related modules

After the modules with highest priority are identified the second step has to be performed. This can be done in a similar way to step one. A matrix for every module assigns for the second step more precise questions to matching methods.

4. Application

We used the new procedure to show how in a project to develop a new noise barrier wall for motorways appropriate methods were selected.
The trigger for the project was that existing walls do not have a very well acoustical performance, that existing walls made of wood do not have a real attractive appearance and that the wood needs impregnation agent for preservation, which turns the ecological material wood into hazardous one. So this was a task to improve quality and reduce environmental impact. We used the questionnaire two times. First time - in the early stages of product development - we started with focus on the questions with indicator Q and E to identify appropriate modules and within theses modules best suitable methods. Table 1 shows the result of this selection procedure.
Second time we used the questionnaire in the later stages of product development. Several questions were then already answered due to applying the adequate methods. So this resulted in a different method selection according to Table 2.

Table 1. Method selection for the early stages of developing a new noise barrier wall

Step 1	Step 2
Modules	Methods
State of Technology	Patent Research
Customer Satisfaction	Interviews
Environmental Analysis	Eco-indicator
Requirements	QFD Phase 1

Table 2. Method selection for the later stages of developing a new noise barrier wall

Step 1	Step 2
Modules	Methods
Analysis to support Idea Generation	Functional Analysis
Combination	Morphological Matrix
Analogy	TRIZ Inventive Principles
Checklists	Ecodesign PILOT

For the selected methods the sequence of use (e.g. first Patent Research, then Functional Analysis, then Morphological Matrix) and the combination of methods (e.g. combining the Ecodesign PILOT directly with the TRIZ Inventive Principles – the classification form contains information about this) can be drawn into the LoM to highlight method application specific for the task in a very concise way.

5. Conclusion

The new approach provides an easy-to-use overview of existing design methods. It is an attempt to look behind buzzwords. The classification of the basic modules includes hints for adaptation and implementation based on practical experience rather then from literature. The classification also points out synergies in the combination of methods/elements of methods.
The new approach can be used to learn about methods and to raise awareness of what is available for supporting design engineers without the necessity of studying extensive handbooks [e.g. Ehrlenspiel 2003] or software databases.
For a specific task (e.g. define new products for future markets, reduce development time, reduce environmental impact, …) the situation questionnaire will identify appropriate basic modules, related methods and combinations thereof. The classification form delivers then essential information for the application.
Furthermore the situation questionnaire can help to look at a product development process from different perspectives (e.g. to overcome the preconception that DfE will definitively add costs). The new approach can be used in every stage of the product development process, from the early phases, where uncertainty is high, till detailed design where difficulties beyond routine demand for method application.

The implementation of design methods in industry is still rather poor [Lindemann 2003]. We propose that the first measure to increase the acceptance of methods is a comprehensive overview - the LoM, which includes a selection questionnaire and implementation hints. This makes sure that the method selection and adaptation fits to a given situation.

Method employment may not be a self-purpose. The new approach clearly indicates the benefits, which are to be expected.

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