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UNDERSTANDING THE CONTEXT OF PRODUCT DEVELOPMENT

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ABSTRACT
Adaptation of design methodologies to the context in which they should be actually applied is seen as a necessity in order to enhance its acceptance and to widen its application. Even though, a context dependent adaptation is seen as a suitable means to make a substantial improvement of current design methodologies, only few contributions were made over the last years, and it often remains somewhat fuzzy what context actually means.
This paper is intended to consolidate the different meanings of context, ways to represent and specify the context and ways to structure the different views on the context.
A scheme for categorising influencing factors is presented. The scheme consolidates factors from literature which have been identified as having an influence on design projects. It is seen as a means to support understanding of a design approach and its context. Therefore, the scheme is a consolidation of existing work, which allows a more comprehensive description and analysis of the context than the more specific lists and schemes from literature.

Keywords: design management, design methodology, design process, organisation of product development

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1 INTRODUCTION

Design problems often do not match the boundaries of a single discipline. As a consequence, designers from different disciplines have to collaborate. In contrast to that, it is observed that much of the developed support, such as design methodologies, are rather mono-disciplinary.

A *design methodology* is "a concrete plan of action for the design of technical systems (…). It includes plans of action that link working steps and design phases according to content and organisation." (Pahl *et al.* 2007). The action plans are supported by methods. Examples of design methodologies as referred to in this paper are Pahl et al. (2007) and Ulrich and Eppinger (2007).

The development of design methodologies is accompanied by an on-going debate concerning their applicability in practice. While many authors highlight the usefulness of design methodologies for training of novices, it is recurrently reported that design methodologies are only seldom applied in design practice (Franke 1985, Jorden *et al.* 1985, Franke *et al.* 2002, Jänsch 2007, Tomiyama *et al.* 2009). An argument usually produced concerns the abstract character of design methodologies (Eckert and Clarkson 2005, Brooks 2010). As they are intended to be applicable in different branches within a specific domain, they propose abstract process models, thus no exact representation of the design processes in each specific branch (Eckert and Clarkson 2005, Wynn and Clarkson 2005). More concrete process models are needed, taking into account the company and project specific context, to customize the methodical support and to improve the feasibility of methodologies in practice.

Currently there are two main axes for further development of design methodologies: the rising interdisciplinarity in design practice which is not sufficiently addressed in the rather mono-disciplinary design methodologies (e.g. Pahl *et al.* 2007, Ullman 2010, Pugh 1991, Dalziel and Ostime 2008, Girmscheid 2007, Kruchten 2000, Sakao *et al.* 2010, Gericke and Blessing 2011) and the adaptation of design methodologies to different contexts (e.g. to a specific branch, company, or product), which is recommended by several authors (Skalak *et al.* 1997, Maffin 1998, Bender and Blessing 2004, Meißner *et al.* 2005, Meißner and Blessing 2006).

This paper addresses the adaptation of design methodologies to different contexts; in particular a concept for a supporting context-specific adaptation of design approaches is discussed.

1.1 Adaptation of Design Methodologies

To allow for a diverse range of possible applications, covering a wide range of different contexts, process models proposed in design methodologies were designed in a generalizing, rather abstract way. The high level of abstraction resulted in a perception of limited benefit because abstract approaches usually provide less context-specific support. Providing a more detailed process model which offers appropriate support for one specific context seems also to be no solution to that dilemma as this would limit the usefulness to this specific context and conflict with the goal to be widely applicable.

Lawson (1997) points out that the ability to manage the adaptation of the design process is one of the most important skills of designers. An approach suggested by different authors (Skalak *et al.* 1997, Skalak 2002, Maffin 1998, Meißner *et al.* 2005) is to start with an abstract, context-independent approach and adapt it to a specific context. Obviously, many designers do this regularly in a successful manner, as they have to align their project plans with a mandatory design approach, e.g. defined in standards or by a company's reference process (Meißner and Blessing 2004, Gericke and Moser 2013).

The requirements for an approach for adaptation of a design process differ with regard to different levels of abstraction. In general, the adaptation of a generic design approach to a specific context requires *augmenting* and *tailoring*. The adaptation of most abstract, generic and branch independent design approaches to the context of a branch or company requires *augmenting*, i.e. the addition of process steps, design practices, guidelines, and other support. The adaptation of a branch specific or company specific approach to the context of a specific project can particularly be seen as *tailoring*. *Tailoring* means that only few additional elements will be considered and the adaptation is mainly a simplification of a comprehensive set of standards, guidelines and pre-selected support. Even though *augmenting* is more prominent for the adaptation on a high level of abstraction, and *tailoring* is more prominent when the design approach becomes context specific, both activities are conducted during the complete adaptation process. Adaptation can therefore be best described as the interaction between *augmenting* and *tailoring* of the provided support and an accompanying detailing of the design process description (Gericke and Moser 2013).

It is assumed that a systematic support for adaptation of design methodologies will contribute to an enhanced impact of design methodologies. Unfortunately, no detailed recommendations or systematic support is offered to adapt design methodologies. Thus, the outcome of adaptation is dependent on interpretation of a design methodology and skills of the particular designer (Gericke and Moser 2013).

1.2 Research need

From the authors' perspective important issues which currently hinder the development of a support for adaptation of design approaches are: a comprehensive understanding of what context means, an empirically based selection of those context-factors which are relevant for adaptation, and an understanding of the rationale of context-specific process adaptation in practice. Therefore, this paper is intended to consolidate the different meanings of context, ways to represent and specify the context and ways to structure the different views on the context.
The work presented in this paper is based on a literature study.

2 WHAT INFLUENCES THE DESIGN PROCESS?

2.1 Context of Product Development

Context is defined as "the interrelated conditions in which something exists or occurs" (Merriam-Webster 2012). Adaptation of design methodologies to the context in which they are actually applied is seen as a necessity in order to enhance the acceptance of methodologies and to widen their application. Even though, a context dependent adaptation is seen as a suitable means to make a substantial improvement of current design methodologies, only few contributions were made over the last years, and it remains at least partially fuzzy what context actually means.
The following section will present different approaches to consider the context in which product development takes place. In order to focus the discussion the emphasis is on influencing factors, i.e. "'people or things having power,' with power as 'the ability to affect outcomes'" (Hales and Gooch 2004, p. 29) referring to (Lawrence and Lee 1984) The term context factor, which is used below, means influencing factor, i.e. a factor having an influence on the course of a design project.

2.2 Schemes for structuring influencing factors

Hales investigated several flawed products and their design processes covering different branches like plant construction, furniture development and consumer goods (Hales 1998, Hales and Gooch 2004). Based on these analyses of flawed products and failed product development processes, Hales and Gooch (2003) provide recommendations for successfully managing engineering design projects, and a set of checklists basing on context factors to support this. The intention of the checklists is to avoid overseeing or forgetting something important and in doing so to reduce the risk of project failure. Hales and Gooch structure the design process according to the approach of Pahl and Beitz (2007) and propose five levels of resolution (macroeconomic, microeconomic, corporate, project and personal) for each process stage (see Figure 1). For each of these levels, checklists are provided with factors that are known to influence the design process.

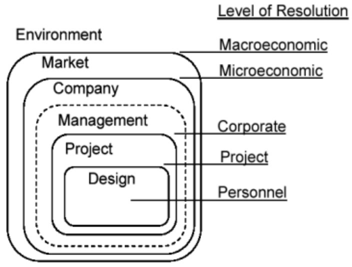

Figure 1: Scheme for organizing influencing factors (Hales and Gooch 2004)

Skalak et al. (1997, 2002) propose a tailoring for small companies, which is intended to adapt a generic process model to a specific project context. The tailoring is based on an assessment of 12 factors. „These criteria do not include other important product planning issues such as team formation, project priority, project cost, or risk assessment. These issues should be addressed in project planning, but are not part of the tailoring process" (Skalak 2002, p. 132). Skalak (2002) proposes to involve representatives from four different areas of a company (design/engineering, process, sales and marketing, and resource management) into the assessment and tailoring process, which should be done in the project planning phase of a design project.

Based on a literature study Maffin (1998) concludes that design methodologies show differences in their underlying approaches, but do not show widespread acceptance in industry. A reason for the limited use of design models as proposed by textbooks is for example the limited awareness of them. “Practitioners often develop own approaches which consider the context in which the product development project has to be executed. (..) procedures usually address what is required to be done as distinct from how it should be done.” (Maffin 1998, p. 316)

Maffin et al. (1997) criticise that existing best practice recommendations do not take into account a company’s unique attributes which may have an influence on the efficacy and efficiency of the proposed design approach and design method. Based on an empirical study of 58 companies in the UK, they conclude, that “it is inappropriate to prescribe generic approaches for companies.” They argue that companies need a support to analyse their processes and key factors which have to be taken into account for aligning their design approach with project strategic policies, general and company-specific, and project specific features. They propose a contextual framework, which is intended to be used for best practice research, i.e. the analysis of the efficacy of design methods and approaches, which serve as the basis for context aware best practice recommendations.

Grabowski and Geiger (1997) aimed to identify strengths and weaknesses of German industry and to provide recommendations to support industry to overcome identified problems related to the structural changes that took place at this time in the German industry. Their study consisted of interviews, workshops and questionnaires involving more than 40 participants (management and designers) from different branches closely related to mechanical engineering. The results of the study were analysed by an expert group (VDI-Arbeitskreis) which identified 11 interdependent problem areas. The problem areas were prioritised by the experts during a workshop. The six most important areas are: cooperation and communication, market and customer, application of methods, people and risk taking, organisation and management, and goal determination. Grabowski and Geiger (1997) provide for each of these areas examples of factors which were identified as having a negative influence on product development projects and propose approaches how to cope with these challenges.

Frankenberger and Badke-Schaub (1998) identified critical situations by observing four development projects in two different companies. Based on their study, they then identified success factors and target effects that contribute to a successful handling of critical situations. Target effects are enablers for a successful handling of critical situations. They can be fostered by improving the success factors. The success factors and the related target effects address the individual prerequisites, prerequisites of the group and external conditions (see Figure 2).

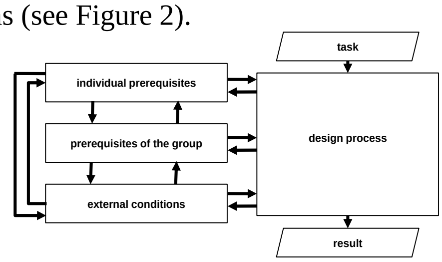

Figure 2: Factors having an influence on the design process (Frankenberger et al. 1998)

Meißner et al. (2005) highlight the influence of the context on the product development process. Based on a literature study they identified factors which are considered to describe the product development context such as market needs, company size, and design task complexity and grouped them into seven categories: society, market, company, design task, resources, team, and individual. They further distinguished the context factors with regard to the level of abstraction of the design process. Meißner et al. (2005) state that abstract process descriptions (e.g. company specific reference processes), project plans, and specific situations within a project are all affected by their context. However, the context factors might not have to be the same for the long-, mid-, and short-term context. Based on this distinction of the product development context Meißner et al. (2005) propose to adapt design approaches in multiple steps, beginning at a high level of abstraction considering the long-term context succeeded by further adaptation steps of more detailed process descriptions (see Figure 3).

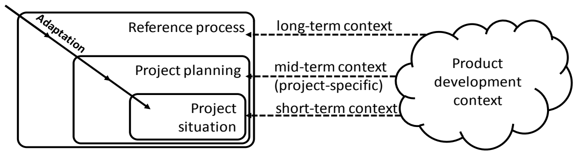

Figure 3. Different levels of context factors (Meißner et al. 2005)

Ponn (2007) differentiates between static and dynamic context factors. He focusses on the adaptation of courses of actions within a design project, i.e. he addresses the adaptation of a design approach on a situational level. According to Ponn, static factors remain constant for the duration of a project; dynamic factors will change during a project.

2.3 Towards a better understanding of context

Managing the course of a design project is usually associated with Project Management, which incorporates activities such as project planning (e.g. staffing, scheduling, budgeting, and risk management) and continuous monitoring of the project's course. Planning the course of a design project can benefit from the support provided by design methodologies, thus a project plan can be seen as a specific instance of a generic design approach as described in a design methodology.

Adaptation of a design methodology to a project's context thus is seen as a support of project management, even though the support provided by the design methodology itself is usually intended to support designing.

In several empirical studies a multitude of factors were identified as having a significant influence on design projects, i.e. describing the main features of a project's context. Dependent on the specific research interest, different schemes for categorization of the product development context have been proposed. Thus, in order to develop a consensus concept for the context dependent adaptation of design approaches it seems necessary to consolidate the existing work on context/influencing factors and the proposed schemes for categorizing them, i.e. analyzing overlap and merging the perspectives for categorization.

3 A SCHEME FOR ORGANISING INFLUENCING FACTORS

The scheme proposed in this paper (see Table 1) considers different approaches proposed by other researchers for taking context factors into account, and provides new perspectives to allow better analysis and description of the factors. The provided list of influencing factors is based on a comprehensive, but not exhaustive literature study. The list consolidates factors identified by empirical studies on:

product development and design management (Burns and Stalker 1961, Hollins and Pugh 1990, Dylla 1991, Frost 1994, Frankenberger 1997, Grabowski and Geiger 1997, Skalak *et al.* 1997, Günther 1998, Maffin 1998, McQuater *et al.* 1998, Schroda 2000, Ehrlenspiel 2003, Badke-Schaub and Frankenberger 2004, Hales and Gooch 2004, Ottosson 2004, Gericke and Moser 2013, Roelofsen, 2011), project management (de Wit 1988, Die Akademie 1997, White and Fortune 2002, Bullinger *et al.* 2003, Engel and Holm 2004), general management and organization theory (Chandler 1962, Woodward 1965, Vahs 2009), and psychology (Dörner 1996).

Context factors identified from literature were analyzed with regard to their congruence, merged in case of contentual overlappings, and clustered (on levels 1 and 2) corresponding to found similarities. The literature analysis lead to 239 influencing factors, which were organized hierarchically on three 3 levels (see Table 1). In the scheme, the influencing factors are structured according to Hales' level of resolution of influencing factors, which is the most comprehensive overview from literature, i.e. the subdivision on the first level is equal to Hales and Gooch's levels of resolution of the product development context (see Figure 1).

The generic character of Hales' model allowed an easy integration of additional factors (on level 3) or set of factors (level 2) identified by other authors. The second level subdivides the 239 influencing factors of level three into 35 sets of influencing factors (see Table 2 in the Apendix).

Other elements of the scheme are the representation of important *characteristics* of the influencing factors, *interdependencies* between the factors, and an assessment of their *relevance*.

Characteristics of the influencing factors are represented by a *description* (verbal explanation or different options of its concretization), and indications of the *measurability* and *dynamic* of each factor.

It is obvious that context factors are interdependent (as studied by e.g. Dörner 1996, Badke-Schaub and Frankenberger 2004), which is not considered in pure lists, but essential for adapting a design approach to its context. Hence, *Interdependencies* between the influencing factors are depicted by using a dependency structure matrix, enabling different analyses of the resulting network of dependencies. The specification of the interdependencies was not possible based on the information provided in the literature, thus would have been pure interpretation and speculation. For this reason the matrix is currently not further detailed, but included in the scheme to raise the awareness of the importance of interdependencies and to avoid a misleading simplification of the adaptation.

The allocation of influencing factors to a *relevance* is intended for focusing on subsets of the identified factors. It incorporates the dynamic and effects of possible parameter values of a particular factor. As a factor can have an impact on strategic, operational, and situational level, the relevance of a factor may concern one or several of the following levels of adaptation:

- adaptation of a design methodology to a branch's or a company's context, i.e. creating a reference process/design guideline – <u>strategical relevance</u>
- adaptation of a company's approach to design to a project's context, i.e. planning a project – <u>operational relevance</u>
- reaction on a specific situation in a project – <u>situational relevance</u>

Table 1. Scheme for organizing influencing factors

Influencing factors						**Characterisitic(s)**			**Interdependencies**						**Relevance**		
Level 1			Level 2		level 3	description	measurability: quantitative/qualitative objective/subjective not assessible	dynamic: static, long-, mid-, short-term	level 1 / level 2 / level 3	1	2	3	4	5	strategical: *adpating a systematic design approach*	operational: *planning the project*	situational: *reacting on a situation*
1	Macroeconomic *(Environment)*		1.1	Cultural	n=5				1								
			1.2	Scientific	n=11												
2	Microeconomic *(Market)*		2.1	Market	n=9												
			2.2	Resource availability	n=6				2								
			2.3	Customer	n=4												
3	Corporate	*a) Company*	3.1	Branch	n=11												
			3.2	Corporate structure	n=13												
			3.3	Corporate systems	n=8												
			3.4	Corporate strategy	n=5												
			3.5	Corporate culture	n=12												
			3.6	Production	n=9				3								
			3.7	Stakeholder	n=1												
			3.8	Suppliers	n=4												
		b) Management	3.9	Shared values	n=3												
			3.10	Management style	n=2												
			3.11	Management skill	n=4												
			3.12	Mangement staff	n=7							nxn					
4	Project		4.1	NPD	n=3							matrix					
			4.2	Project management	n=12												
			4.3	Design team	n=20												
			4.4	Team output	n=4												
			4.5	Working environment	n=1				4								
			4.6	Design task	n=35												
			4.7	Use of design tools and methods	n=15												
			4.8	Production	n=2												
5	Personnel		5.1	Knowledge	n=6												
			5.2	Skills, competencies,	n=13												
			5.3	Individual styles (ways) of thinking and acting	n=1												
			5.4	Attitude	n=10												
			5.5	Motivation, emotion	n=5												
			5.6	Performance (ability to perform)	n=1				5								
			5.7	Output	n=3												
			5.8	Relationships	n=3												
			5.9	Gender	n=1												
			5.10	Age	n=1												
			sum	**=35**	**=239**												

(Callout to 4.2 Project management:)
4.2.1 project motive
4.2.2 project boundary
4.2.3 restrictions
4.2.4 feasibilty of technical requirements
4.2.5 forecast reliability
4.2.6 information basis for decision making
4.2.7 feasibility of schedule
4.2.8 permitted product cost
4.2.9 adequacy of project organisation
4.2.10 quality of process description
4.2.11 adequacy of project resources (people, budget, …)
4.2.12 qualification of project partners

4 DISCUSSION

4.1 Means for reducing the complexity of the network of influencing factors

Interdependencies between factors raise the complexity of the interrelationship between characteristics of influencing factors and resulting effects. In order to develop a systematic support for adaptation, these interrelationships have to be simplified. Possible ways to do this are:

- Gathering comprehensive empirical data to specify influencing factors and their possible characteristics, their interdependencies and effects on the design project, in order to provide recommendations, e.g. on how someone should act in different situations.
- Prioritization of factors regarding their effect from a specific perspective (strategical, operational, situational) and neglecting less important factors.

Detailed recommendations for context specific adaptation of a design methodology, which are based on a comprehensive empirical data-set, would be, of course, ideal. But this approach has two major limitations. First, it is obvious that it is very difficult or rather impossible to gather the required empirical data and keep the data set up to date. Second, many of the influencing factors (respectively their characteristics) can be neither quantitatively nor qualitatively assessed, respectively the assessment is prone for being biased by the subjective perspective.
An alternative is to support the analysis of an individual network of influencing factors in a specific context. In order to reduce the effort for analyzing all possible influencing factors, their characteristics and interdependencies, a prioritization of highly relevant factors seems necessary, i.e. highly relevant for adaptation dependent on the individual motive (strategical/operational/situational adaptation).
According to the proposed scheme, the analysis may start on level 1, be continued on level 2 and brought to completion on level 3. Besides decreasing the complexity of context analysis steps this approach will reduce the analysis effort, as a group of factors which is assessed as being not relevant can be omitted as a whole, while pointing the attention of the person managing the adaptation to more relevant factors which may be overseen otherwise.

4.2 The relevance of influencing factors for adaptation

An overview about the complete list of factors, which of course is subject to further extension, and a comprehensive analysis of the specific context is seen as a means to develop the necessary mind set for adapting and managing design projects properly (as discussed by Lawson 1997 and Hales and Gooch 2004)
Further, the question arises whether individual factors (level 3) or sets of factors (level 1 & 2) can be described with respect to their relevance for the different levels of adaptation (strategical/operational/situational). The empirical studies, which were analysed in order to gain an overview about factors having an influence on design projects, had their own specific research focus, usually being different from issues of context dependent adaptation of design approaches. Therefore, the data provided by these studies is not sufficient for specifying the individual relevance of context factors.
Further empirical studies are required in order to provide an improved guidance for analysing product development context. It is expected that, based on such studies, at least characteristics of groups of factors can be assessed in general to determine their relevance. The determination of the relevance will presumably not be exclusive, i.e. sets of factors can be relevant for different purposes, even though a general dependency is apparent. Factors on macroeconomic and microeconomic level are commonly less dynamic than factors on project and personal level. It is further expected that less dynamic factors have a rather strategical relevance and dynamic factors tend to be more relevant on operational or situational level.
At the current stage of the proposed approach, the assessment of context factor characteristics has to be done in each application of the scheme. Even though, a support for adaptation should be simple and as less as possible time consuming, the complexity of design practice requests a careful, not oversimplified analysis of the context. The assessment should not lead to a selection of relevant factors or a deletion of factors from the list, but give rise to a prioritisation of factors which are likely to be relevant in a specific context. A selection of factors prior to an analysis of interdependencies between factors could be a misleading simplification, as interdependencies having a determining impact could be blanked out.

4.3 Adaptation is not a passive process

Considering the interdependencies between the factors which were identified to have an influence on the design project, it becomes obvious that the design approach (i.e. design process, methods and tools, etc.) itself has an influence on factors, i.e. the relation between a design approach and a specific context is bidirectional. Thus, adaptation of a design approach is not a purely passive process, which is dependent on a given context; adaptation can also actively affect the context in order to improve the fit between a selected design approach and a specific context. In consequence, an adaptation will affect the context where it is intended to be applied. During the adaptation, the analysis of the context may support the definition of prerequisites and requirements for implementing a design approach and provide guidance for a change process.

5 CONCLUSION

A sound understanding of the development context is a precondition for successful adaptation of a design approach. Therefore, the analysis thereof is seen as a necessary learning process.The presented scheme for categorising influencing factors provides a support for the analysis of a specific product development context, which should happen prior to the actual adaptation of a design approach to that context. It can also be used for further research on this topic.

The scheme builds on schemes and lists of factors from literature which have been identified in empirical studies as having an influence on design projects. Therefore, the scheme is a consolidation of existing work, which allows a more comprehensive description and analysis of the context than the more specific lists and schemes from literature thus expected to of value for design practice and design research.

The provided scheme is seen as a means to support understanding of a design approach and its context. Even though, the scheme does not hint to specific practices and means for adaptation, it provides a structure for an analysis of the context and for identifying opportunities for a process improvement.

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APPENDIX

Table 2. List of influencing factors (level 3)

1	
1.1	Professional training
	Socialisation process
	Family background
	Cultural background
	Firms cultural norms
1.2	Social Issues
	Political Climate
	Infrastructure
	Economic Situation
	Job market
	Taxes
	Support programme
	Legislation
	Technological Advances
	Ecological Concerns
	Luck/Chance

2	
2.1	market share
	market size
	market structure
	Demand
	Commitment of sales department
	Competition
	Industry
	export share
	Financial Risk
2.2	Human Services
	Capital Finance
	Information for Design
	Appropriate Technology
	Appropriate Materials
	Appropriate Energy
2.3	Understanding of Need
	Urgency of Need
	Expectations
	Involvement

3	
3.1	
3.2	Span of Company
	Size of Company
	legal form of company
	Hierarchies
	Coordination and division of work
	Autonomy
	Age
	Type of Project Control
	Financial resources
	company's crisis situation
	Company's development stage
	Product development history
	Product portfolio
3.3	Help Getting Information
	Quality of Work Environment
	Pay Scales and Benefits
	Retirement security
	working time
	training provision
	Labour union
	level of bureaucracy
3.4	Clarity of goals
	Dynamics of corporate goals
	Scope of planning/strategy
	Level of Risk Taking/Innovation
	R&D / Product development strategy
3.5	Working climate
	Responsibility
	Politics between departments
	Cooperation between departments
	Collaboration/Integration of specialists (e.g. industrial design)
	creative leeway
	Informal communication
	Authority
	Management Support
	Trust and openness
	Warmth and consideration
	Reward and recognition
3.6	flexibility
	Complexity of production/manufacturing technology
	production depth
	cycle time
	available capacity
	available manufacturing technologies
	materials management
	logistics
	Laboratory - product testing
3.7	Stakeholder
3.8	Collaboration with suppliers
	Availability
	Interfaces
	Location
3.9	Degree of Commitment
	Degree of Involvement
	Degree of Project Enthusiasm
3.10	Degree of Staff Freedom
	Degree of Staff Participation
3.11	Quality of Planning/Coordination
	Quality of Communication
	Effectiveness of Project Support
	Effectiveness of Resource Use
3.12	Number of Staff Involved
	Quality of Judgement
	Degree of Motivation/Morale
	Senior management support
	management experience
	quality of leadership
	Degree of Confidence

4	
4.1	NPD Culture
	NPD Strategy
	NPD Organisation
4.2	Project motive
	project boundary
	restrictions
	feasibilty of technical requirements
	forecast reliability
	information basis for decision making
	feasibility of schedule
	permitted product cost
	adequacy of project organisation
	quality of process description
	adequacy of project resources (people, budget, …)
	qualification of project partners
4.3	Group organisation
	informal hierarchy
	Division of labour
	Team work standards
	Expertise (Competence)
	Experience
	Role Balance
	Cooperation
	Communication
	discussion culture
	Commitment
	Motivation
	Group climate
	Morale
	Negotiating Ability
	power
	Leadership power
	Negotiating Power
	User Involvement
	Cross-functional interaction
4.4	Productivity
	Pressure to succeed
	Failure cost
	Quality of Work
4.5	Working environment
4.6	Quality (and invested effort) of task clarification
	Priority
	Cost
	Sales target
	Design cycle time/duration of design project
	Ambiguity
	level of constraints/flexibility of requirements
	Interdependence/contradiction of goals/requirements
	Product variety
	Dynamics of requirements
	Polytely
	Magnitude
	Complexity
	Potential for decomposition into subsystems
	Required knowledge
	Required analytical resources
	Available (provided) information
	Availability of required information
	Currentness of information
	Novelty
	Innovativeness
	existing patents - intellectual property rights
	Customer topology
	Number of vendors involved
	Required quality
	Acceptance of proposed solutions (concepts)
	Technical Risk
	Project risk
	Technology
	Process
	Material
	Equipment
	IT
	Knowledge
	Delivery Time Constraints
4.7	Systematic Approach
	flexible approach to change
	Formal Design Methods
	Intuitive Design Methods
	Effort related to methods
	applicability of methods
	sharedness of methods across departments
	support of application of methods
	Open-mindedness regarding new methods
	Support of communication
	Project Control
	Support of (interdisciplinary) collaboration
	Computer Design Methods
	IT support
	Codes and Standards
4.8	manufacturing technologies
	batch size - level of standardisation of job execution

5	
5.1	Knowledge Base
	Experience
	Facts (expertise)
	methods
	heuristic competence
	Knowledge Applicability
5.2	Perception
	Use of Knowledge
	Communication
	Creativity (Imagination)
	Versatility
	Negotiation
	Spatial thinking
	Analysing
	Synthesising
	Problem-solving competencies
	social competencies
	Sketching
	Drawing
5.3	Individual styles (ways) of thinking and acting
5.4	value system
	open mindedness
	assertiveness
	Individual work Standards
	Self-Discipline (Habits)
	Self-confidence
	Integrity
	Accuracy
	Willingness to learn
	Individual time pressure
5.5	Enthusiasm
	Involvement
	Tenacity (Determination)
	Frustration/Anxiety
	Humour
5.6	
5.7	Productivity
	Confidence in own work
	Quality of Work
5.8	Team Role Compatibility
	Relationships within Company
	Relationships outside Company
5.9	Gender
5.10	Age