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NEXT GENERATION BUSINESS ORIENTED AND USER CENTERED DESIGN MANAGEMENT APPROACH

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ABSTRACT
During the year 2008, it has been interesting to see just how interlinked the financial systems in the world really are. Designers have to carefully take consider of the affects of turbulences in business environment when considering the design management issues targeting to the life-cycle long value creation process of the product. The approach taken by this research considers the right kind of design process for a certain business need by viewing two modern design management approaches considering viewpoints critical for maximizing the value creation capacity of a product in a time scale. The subject is approached by carrying out an analysis based on some of the latest research in the design management field. The design approaches evaluated are the Company Strategic Landscape (CSL) and the Inclusive Design toolkit. These two approaches are extending the traditional scope of design methodologies. CSL represents the business oriented product structuring method connecting design decisions to business environment in a structured manner and Inclusive Design toolkit brings forth the user centeredness connection to a design process. Examination of advanced design techniques is essential because the cost of bad design is too high – bad design decisions decrease the value creation for the process owners during the product life-cycle. The modern business- and user oriented design management approach utilizing the benefits from both approaches is introduced.

Keywords: Design management, product structure, value-chain analysis, business goals, user-centeredness

1 INTRODUCTION
This paper views the foundations for designing products with high life-cycle-long value creation capacity. The topmost mission in defining the right kind of design process for a concept is to understand the design context and the ways the business environment directs requirements to a design process. Hubka & Eder [1] stated in the "Theory of Technical Systems" (TTS) that a technical system should not be evaluated according to its implementation but according to its use cases. This Design Science originated approach names the needs and demands targeted to system as a starting point for examining technical systems. "Design Science" refers to product design approach by Design Society founded in 2001. The founder of design society is the WDK School (Workshop Design-Konstruction) and the approach is strongly based of the ideas presented in "Theory of Technical Systems". Roots of Design Science are in German design school. TTS presents a description of a transformation process common to all technical systems indicating the causality and existence of technical system in several abstraction levels. The foremost goal of this "meta" description is to enable creation of information and knowledge that is transferable among technical systems [1].

The design approaches presented next are refining the ideas originating from TTS by aiming to understand the needs and demands targeted to design and viewing the design problem in several design abstraction levels. Creation of information and knowledge needed to define a suitable design process for a concept is done by breaking out from a traditional design formula. This means viewing the definition of a design process as comprehensive task including the examination of business environment and user capabilities.

2 COMPANY STRATEGIC LANDSCAPE (CSL)

2.1 Introduction

Company Strategic Landscape (CSL) is a design management approach model describing the key issue domains guiding the product structuring decisions and the contents of the relations between the domains. It provides a framework for evaluating the business effects of design decisions and using this knowledge to define product structures. It creates an understanding of how business demands are connected to product structures. By applying CSL approach the value creation potential of new concepts and the requirements for a design process can be defined. CSL was first introduced by Riitahuhta research group of Tampere University of Technology Finland in 2007 and it is based on numerous major industrial cases and doctoral thesis studies carried out during the last ten years. Evaluation of the business effects of design decisions and creating an understanding of how the demands arising from business goals can be connected to product structures is originally presented by [2] introducing a method for forming target model guiding the definition of product architecture. In the doctoral dissertation the connection between designing new modular product architecture in new product development and the CLS approach is indicated and used for defining product structures that corresponds the needs arising from the business goals.

The main idea behind the CSL approach is that market position of the company and the strategic goals it chooses to pursue, define the way products have to be structured. Product structure either enables or inhibits the realization of business goals. By taking business oriented viewpoint for designing new products we create the opportunities for not only to recognize the ways the value is created and captured during the life-cycle of the product, but to do the design in a way that responds to varying needs of business environment. In dynamic and global markets it is highly important for companies to be able to reach a certain level of reactivity to push out the right kind of products in a right time, and at the same time to optimize the value creation using design constants and variables available.

2.2 Defining the optimal product structure

CSL approach extends common design approaches a step further to better understand the entire design scene. Goal is to create an effective design management method for this rather complex problem solving field. As an addition to approaches represented in the research field of product design and structuring the CSL approach takes a step towards more integrated, business goal oriented approach for defining product structures.

Erixon introduced a list of module drivers in his Modular Function Deployment (MFD) methodology [3]. In MFD approach the “module drivers” represent the motivations (or reasons) for structuring a product in a certain way. MDF then defines reason logic for why a design should be structurized in a certain way reflecting the needs arising from the business environment. Erixons module drivers could be seen as “general regularities” guiding the design decisions according to business needs. As refined from Erixons approach the relations connecting product design decisions and value-chains of a certain business process are target of examination in CSL approach. However, to use these regularities as tools for making the design decisions they should be wrote out to in such detail that the direction and extent of the effects they target to design can be calculated. By taking the idea of the “module drivers”/”general regularities” - the laws of the relations driving the product design decisions further, CSL model creates a better understanding of how to define a connection between the product structure and value creation.

Business oriented product structuring method consists of CSL approach and the Value Creation and Capture Analysis (VCCA) tool where CSL forms a framework for VCCA. Figure 1 introduces a graphical description of CSL model pointing the two-way relations between the structural characteristics of the product and the business processes connected, delivering the value during the product life-cycle. Figure indicates the CSL framework by naming the business process areas (domains) forming the mechanisms of value creation and value capture during the product life-cycle. These processes take place in the parts of the value-chains that company, using the product, takes part in. CSL breaks out from such design approaches that focuses purely on the technical solutions in defining the right kind of design process.

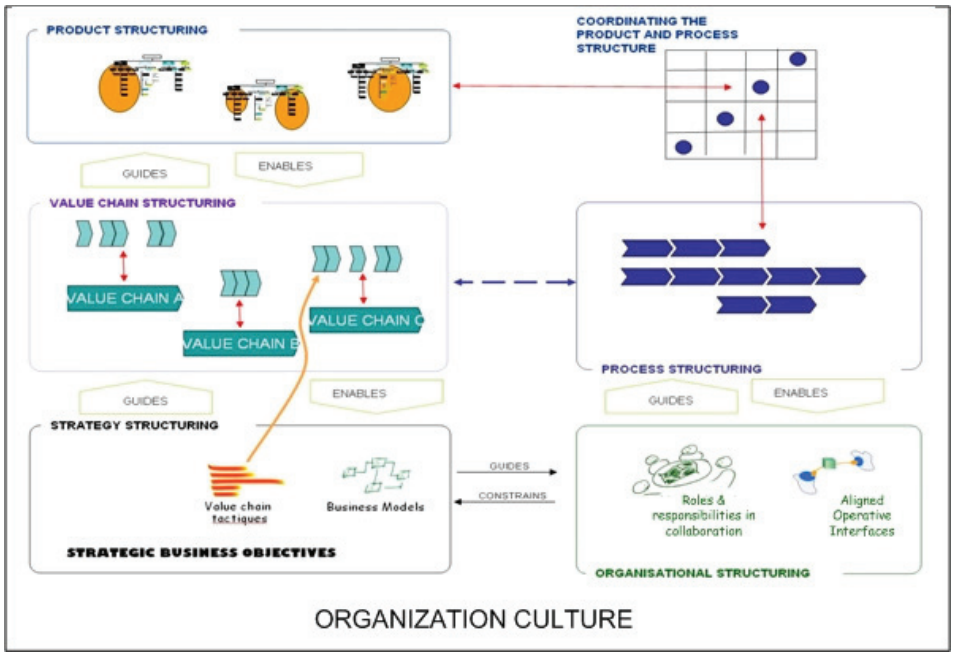

Figure 1. Company Strategic Landscape -model (CSL) is a framework for defining product structures that meet the business goals. It comprises the business domains and the relations between them.

Critical domains for the product structuring and the contents of the relations between them are described in a figure 1. Strategic business objectives structuring of the organization and the business goals guides and limits relations between the other domains. Strategy structuring and product structuring define the possibilities to create and exploit value during the life-cycle of the product. Strategic business objectives of the company define the parts of the value-chains in a business process that are chosen to create value to the company. Secondly, the product structuring domain (upper-left corner) defines the limitations and possibilities targeted to design process. These limitations of are for example technological and structural characteristics, or laws of physics, of a concept and they are the definers of the value creation potential for that concept. The processes affecting to product structure decisions; sales, design, and production are shown in the middle on the right-hand side. The structure of the internal resources and the organization network and the selected methods, operative interfaces, guide the process structuring and constrains the strategy implementation (down right-hand side).

Organization specific cultures, fundamental set of assumptions, values and ways of doing things structure the way its processes and operations are defined and carried out [4]. This is why CSL approach is not complete without considering the organization structure, -history and -culture -related influences for a certain business.

2.3 Cost modeling - defining the impacts of design decisions to the value creation potential of a concept

2.3.1 The disposition mechanisms

Division of the product life-cycle, product structure and work processes into elements pointing out the mechanisms that create the value and the costs forms a challenging mission. This kind of design approach is basically regeneration from "The Concept of Dispositions" [5] which proposed the dispositional mechanisms - chains of relationships in the course of a production sequence. This means that every design decision has its effects on different parts of the product life-cycle and these

dispositions have to be understood to manage the design process. Improper dispositions can lead to degraded or expensive products while good dispositions can lead to ideal conditions even in other business areas. The concept of dispositions proposes that there is a need to isolate dispositional relationship in order to use this very powerful rationalization tool in industry. As a comparison the viewpoint in [5] the CSL approach represents a two-way approach to examine dispositions. It means that while concept of dispositions [5] regards the impacts of design decisions for later stages of product life-cycle while CSL also considers the impacts caused by life-cycle phases towards the design decisions.

2.3.2 The VCCA tool - Analysing the life-cycle costs of the end product

In the research work of Cantamesa and Rafaele [6] the implications of the product modularization for the management of innovation and for new product development was considered. The definition of a product life-cycle was set as for the basis of the reason hierarchy defining the product structure. The same elements are used in CSL model but [6] did not evaluate the relations between the design criterions (reason elements) as done in CSL. The life-cycle effects of products as a combination of different life-cycles was examined by Umeda, Nonomura, and Tomiyama in ”Study on life-cycle design for the post mass production paradigm” [7]. They stated that optimization of some business goals during the product life-cycle often happens with the cost of the other goals and different life-cycle options can cause remarkable variation in total life-cycle value of the product. Minimizing the life-cycle costs did not necessarily produce the optimal solution from the total value creation perspective. Research also highlighted the fact that market prices do not change in the same pace with the total profit curve of the product. Findings highlight the importance of understanding the mechanisms of value creation and value capture during the product life-cycle. According to the value-chain based product structuring method presented in this paper, product structures can be optimized to fit selected life-cycle types by applying CSL approach. In the study of life-cycle design for the post mass production paradigm [7] only the target architectures of the modular system were defined. CSL takes the life-cycle design approach for a step further by stating how the product structures actually can be defined using the value-chain analysis process. Optimization done by utilizing VCCA tool of CSL approach is multiple criteria optimization examining situations in which decisions according to product structures are being made. Optimizing one design quality can also effect negatively to the other. To be able to fully exploit the possibilities that CSL approach is able to offer the simulations illustrating the effects of the design decisions are built. That can be done for example in graphical form. Also techniques like Monte Carlo simulations and sensitivity analysis are used to identify the critical design optimization parameters.

2.3.3 The design process -related regularities defining the reasons and the effects of design decisions

The most difficult part of the product life-cycle cost modeling is to recognize the process-related regularities described as “the main rules”. “The main rules” are partially based on the concept first presented by Erixon [3] at his dissertation. Erixon introduced the Modular Function Deployment (MFD), the approach for product structuring. It defines the product modularity without the aspect of functionality (traditional way of approaching product structure). In MFD approach the concept “module drivers” is introduced as describing the defined reasons as for the basis of concept decomposition into structural elements forming the end product. These design modules are categorized according to effects they have on product structures. The motivations of module drivers are defined as [3]; decomposing the product module into different uses, long term management, configuration and manufacturing related reasons, maintenance and environmental reasons. As a comparison to “the main rules” -approach of CSL, Erixons module drivers work as a generic template. As an addition to module drivers presented in MFD, the main rules -approach in CSL also explains what effects do the drivers of design decisions have on certain product life-cycle. So, as an addition to the motivation of the design decisions the general regularities called the main rules also explain the consequences of the design decisions.

3 INCLUSIVE DESIGN TOOLKIT

3.1 The waterfall model

Inclusive design toolkit is a design approach developed in Engineering Design Centre at the University of Cambridge. It highlights the user centeredness, population awareness and the business goals in making good designs. Inclusive design toolkit sets functionality, usability, desirability and viability as the measurements of a good design [8] and strives to relate the capabilities of the population to the design of products by effectively characterising the user [11]. Population awareness means understanding of the statistical structure of the population pointing out the variations such as the age structure and prosentual amount of certain disabilities in a population. Ignoring the user centeredness issues can have dramatic affects for the usability of the end product. The case example of bad design in video recorders was introduced in [10]. Connecting video cassette recorder to TV required handling several wires and performing different switches which made the system very complicated to use.

The topmost goal of inclusive design is to produce products that are accessible for as many people as possible. Accessibility means the possibilities to use a certain product. It might be limited by such factors as poor usability, complexity of the product or the physical limitations of human capabilities. The waterfall model in figure 2 describes the basic process of Inclusive Design toolkit, the transformation from a need to design solution.

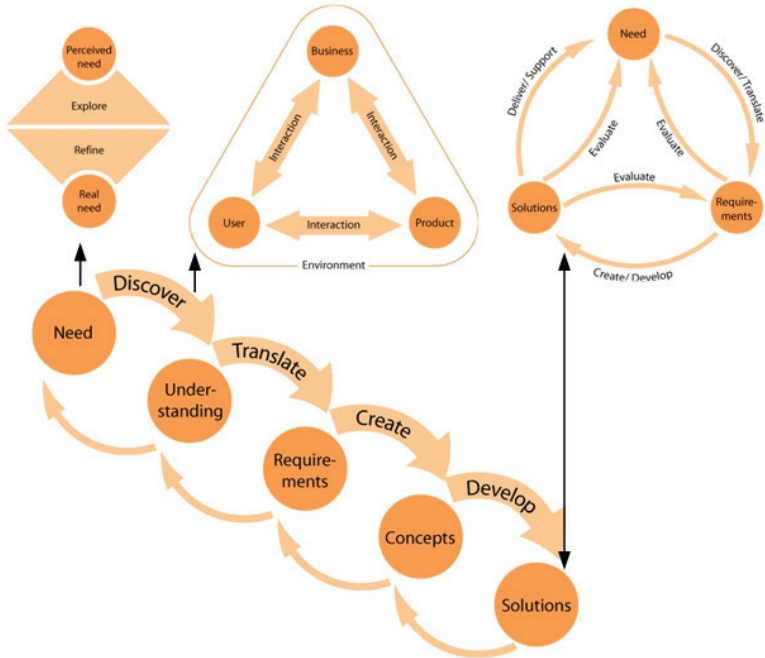

Figure 2. Waterfall model. Design management approach by Inclusive Design toolkit [8]

Inclusive Design process starts from discovering and understanding the needs targeted to design. When the initial need is understood the real design need can be determined. Interactions between the users, products, and businesses in certain environment are recognised to understand the needs. The user-product interaction means recognizing the use-environments that create different user experiences while product is used. Consideration of different use scenarios, and that way the requirements targeted to products in different use contexts, is important part of defining needs targeted to design.

Understanding the business needs targeted to design contain specifications of [8]:

- Business objectives (market share, margins, time to market and ROI etc.)
- Available resources (budget, timescales or personnel etc.)
- Corporate fit (other products, strategies, brand etc.)
- and the interaction between these factors.

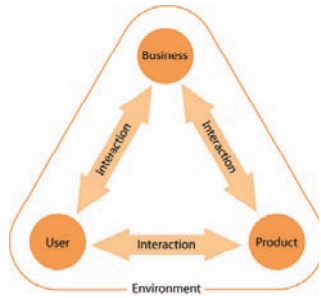

Figure 3.Triangle of needs targeted to design [8]

Considerations of the user needs views, the market segmentation, personas, capability losses, product interactions, tasks, and goals. Understanding of the initial needs is translated into requirements in waterfall model. Requirements are used to create the preliminary concepts of design which are evaluated against the requirements. Translating understanding into requirements contains definition of the tasks and functions, life-cycle requirements, principles for good design, and structuring of the output. Good requirements specification should be solution independent, specific, objective, and quantified where possible, measurable and testable, traceable so that the source of the requirement is understood [8]. As an addition requirements should be accurate in their representation of the true needs, complete and well structured. In development phase the final product is created which leads to solutions answering the original needs.

3.2 Strategic approach for design management – understanding the context

The SPROC (Strategy, Process, Resources, Organisation, and Culture) model describes the critical design factors from the business strategy point of view. According to Inclusive Design toolkit -approach these five elements are critical for designing products which create value to the company by intended way during the product life-cycle.

Figure 4. SPROC Model. Strategic design approach by Inclusive Design toolkit [8]

In order to design products creating expected value during their lice-cycle the strategies and processes of a company should support Inclusive Design approach and the resources needed to implement Inclusive design process should be recognised. The organisation structures and systems and -culture should be set to support the Inclusive Design to achieve good design.

4 DESIGN TOOLS

4.1 VCCA (CSL) – Defining the product structure based on business goals

The Value Creation and Capture Analysis -method (VCCA) is a tool for utilizing CSL approach. It defines the two-way relations (or dispositions) that point out general regularities guiding the product structuring decisions. The dispositions have earlier been studied for example by [5] and the VCCA

method is partially based on that research. Traditionally product structuring decisions have been examined only from the costal perspective and with a little focus on dispositions. VCCA method defines a four step approach for pointing out the connection between product structures and strategic objectives of the company and defines the optimal structure for a product:

Step 1 - Defining the life-cycle model for the product
Definition of a value-chain starts from detailed description of product life-cycle model.

Step 2 - Defining the value creation and capture model
Mechanisms creating the value and the costs for the company during the product life-cycle are defined. Based on the definition of value creation and cost mechanisms producing money flows we create a model that classifies the value creation mechanisms and cost sources. The cost sources are classified into three categories, product life-cycle related factors (e.g. design-, assembly-, recycle costs), work/use -cycle related factors (e.g. process materials and energy - often variable costs) and the investments/ financing costs. As a result, the events that cause monetary inflow or outflow during the product life cycle can be identified. When elements creating value for the company and the ones producing costs are added to life-cycle phases, we have a model that illustrates the inflow and outflow of money in different phases of product life-cycle.

Step 3 – Decomposing the product into elements - structuring the product
The next stage is to divide product into reasonable design elements. This is done by considering the value creation and cost mechanisms during the product life-cycle and their relation to the structural characteristics of the product. The division is critical for the modeling tools to produce valid information as for a base of design decisions. This kind of division method emphasizes both economical and technical aspects in defining the proper product structure for a concept.

Step 4 - Forming the calculation model and its relations
Product design is now divided into elements according to value creation elements producing incomes- and outcomes in different stages of a product life-cycle. The next step is to define the monetary value of each design element defined in the design. This is done by first creating a meta-model. Based on that, the connections that point out general regularities (see 2.2), guiding the product structuring decisions, can be seen. Now the total value of a certain product design and delivery concept can be calculated and the comparisons between different design concept options can be performed. In step 4 the constants and variables of the calculation model defining the total value creation potential of a certain product concept life-cycle option are defined. Especially when dealing with complex products, this forms a challenging task requiring both deep technical and business knowledge base. Constants and variables often have to be defined as calculatory averages from several initial values.

4.2 Inclusive Design toolkit - Portfolio management approach

Portfolio management approach taken by EDC Inclusive Design, aims to maximise the profit by allocation of the resources in design process to meet the business goals. Matching the product to answer the needs of chosen market segments is done by overviewing the product offering of a company and forming cost effective portfolio structures to improve the effectiveness of a design process. The main goals of portfolio management approach are [8]:

- Maximizing the value of the portfolio
- Ensuring a balance between risk and reward
- Ensuring strategic alignment within the company
- Matching the projects with available resources

Portfolio management helps to define different variations of designs for different customer segments to meet the business goals in long-term. Customer segment information includes statistics and analysis about the structure of the population. Aim is to use same components in different portfolios as much as possible and same product platforms inside the portfolios for different product variations. This way as many customer segments as possible can be achieved by manufacturing as few components as possible. Consideration of platform projects as surfaces for the products with common components and characteristics helps to avoid redundant projects during the product life-cycle. Style guides of

product portfolios refer to common design rules (or patterns) that can be used in different levels of organization to control the overall principles of design. Patterns refer to optimal solutions to a specific problem. Style guides lead the design decisions made according to common principles set by company strategy. With portfolio approach it is easy to apply Inclusive Design principles for different product families corresponding to certain customer segments with definable qualities and disabilities.

The Inclusive Design toolkit suggests combining the requirements targeted to design to different life-cycle stages by using the requirements matrix. The matrix describes the different phases of product life-cycle and the requirements targeted to them. Requirements are divided to performance-, cost- and process requirements. Performance requirements include variables like geometry, appearance, and usability issues. Cost requirements define the material, labour and other target costs for the life-cycle -phases while process requirements include process related capabilities and limits set by for example scheduling.

Functional analysis is used to connect the requirements targeted to design in different functions and their sub-functions. The Inclusive Design toolkit utilizes the Functional Analysis System Technique (FAST) for describing the high level functions and dividing it into functions and their sub-functions. Life-cycle analysis represents the functions in different life-cycle phases of the product and aims to define the requirements targeted to each of the functions.

5. SYNTHESIS FROM CSL AND INCLUSIVE DESIGN TOOLKIT DESIGN APPROACHES

Both approaches CSL and Inclusive Design toolkit view the design process from a wider perspective than the traditional approaches which are merely concentrating on product structures. This can be stated by examining SPROC model and CSL framework and Design Science theories. Inclusive Design and CSL approaches agree that the motivation and goal setting for the design process has to originate from a strategic business level. According to [9] the development of technical system with ability to react to changes in business environment requires definition of the fit between the domains described in CSL framework model; design goals, design processes, project management processes, product structures and the organization (see figure 1). Creating this kind of understanding requires effective design coordination. Without the acceptance and the commitment of the upper-level management the realization of good design will not actualize. Managers are in the position to tie the resources and design goals together and guide the focus of the design process for right direction in a long term. By effectively managing the fit between the domains defined by CSL, R&D efficiency can be increased and less waste effort is used in design and in management [9]

Dispositions theory [5] has led the way to CSL approach by addressing that the disposition rules, that is, the chains of cause-effect relations originating from earlier decisions in different areas of the company, are guiding the design decisions. The Concept of Dispositions states the importance of recognizing the mechanisms guiding the dispositions, and showing how to handle them in industrial circumstances. CSL approach brings forth the areas causing dispositions and points out how the connection to design decisions is made. This creates an understanding how the right kind of design originates from the business goals, that point out the value capture mechanisms in value chains, and that way set the rules to the kind of design structure that supports the value creation process. CSL on the other hand do not pay much attention to user centeredness but analyses the value for all relevant stakeholders. As the figure 2 points out, the Inclusive Design toolkit takes more focused approach by suggesting the waterfall model for recognizing the “dispositions” (design rules) that originate from the triangle of the needs targeted to design (business, product, user). Inclusive Design toolkit utilizes acknowledged tools such as portfolio management, user categorization and task/life-cycle analysis to guide the design process. Different user -related evaluation tools are used throughout the design process to evaluate concepts from end user perspective.

Design approach elements of Inclusive Design toolkit can be found from the CSL. The orientation of Inclusive Design however is targeted more on wide applicability of products among the end users while CSL explains how the whole business field including all the domains (figure 1) is connected to design decisions. Both approaches agree that initial (perceived) design need(s) can originate from

different sources as being market-pull, technology-push or for example changes in business environment. Inclusive Design approach states that the exploration of the design context will ultimately lead to the identification of the real needs behind the initial design challenges and the requirements originating from these needs are then used to create the preliminary concepts. Inclusive Design toolkit suggests a creative process utilizing e.g. mind maps, lifecycle maps and filtering to cluster and rank the best ideas based on requirements. The concepts are formed based on this creative process as seen in figure 5.

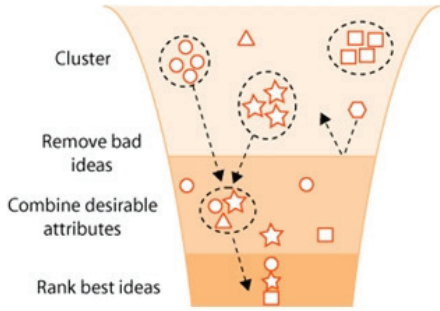

Figure 5. The filtering process for ranking the best concepts [8]

Inclusive design toolkit offers a tool for CSL to rank ideas for potential concept options, which then are analysed by utilizing VCCA tool. CSL on the other hand provides criteria's for filtering and ranking while Inclusive Design toolkit approach does not define any structural logic to define concepts for a certain business. It merely suggests creative tools for ranking the best ideas. This paper however states that this process should be controlled in a structured manner which makes Inclusive Design approach as being unable to define the optimal product structure by itself.

Other reason for the statement for Inclusive Design toolkit being a potential utility for CSL approach is that the portfolio management approach can be utilized to allocate the requirements targeted to design process, originating from different stakeholders and affecting to different domains in business environment. Portfolio management however is unable to allocate all the requirements targeted to product structure and understand the nature of their connections to design process. The connection between the product structure and the design process is dynamic. The form and nature of dependencies vary in time and this interaction has to be acknowledged and managed correctly. Definition of a design process is dependent on product structure type (see.fig1 and CSL description). Project management on the other hand has to fit to the design process selected to support the product structure type. This means that for a set of certain design tasks a specific set of milestone- and goal criteria's supporting the selected design process can be defined [9]. CSL points out what the design context -field is and how the needs behind design challenges are actually identified and connected to design decisions in a structured manner. CSL then answers the questions "why" and "how" and portfolio management tool helps to manage the understanding based on this knowledge.

5 CONCLUSIONS

As the underlying goal of the Concept of Dispositions -approach is to understand the nature, type, placing and effects of dispositional mechanisms [5] the CSL approach appears as further analysis process for it and Inclusive Design as a tool for connecting some dispositions to the design process. In CSL, requirements targeted to design are defined by analysing the domains of business environment (figure 1) which product (structures) are connected to during their life-cycle. VCCA method provides a tool for determining the optimal structure for the design by unveiling the value creation and value capture relations and dispositions along the product life-cycle. Inclusive Design approach suggest a waterfall model emphasizing the market segments and the capabilities of the end users, use situations and fit to business as a basic approach for structuring products. Portfolio management, product and technology platforms, and style guides are introduced as tools that can be used to manage the overall

product strategy [8]. This research states that in order to define a product structure including all the domains directing requirements to product structure Inclusive Design toolkit can be set as an accessory for the CSL approach. Inclusive Design toolkit strengthens the user centeredness aspect and that way adds critical understanding to CSL. These two design approaches can then be stated to be complementary and on the other hand not completely comparable. In figure 7 the hierarchies between the design approach concepts of this paper are presented.

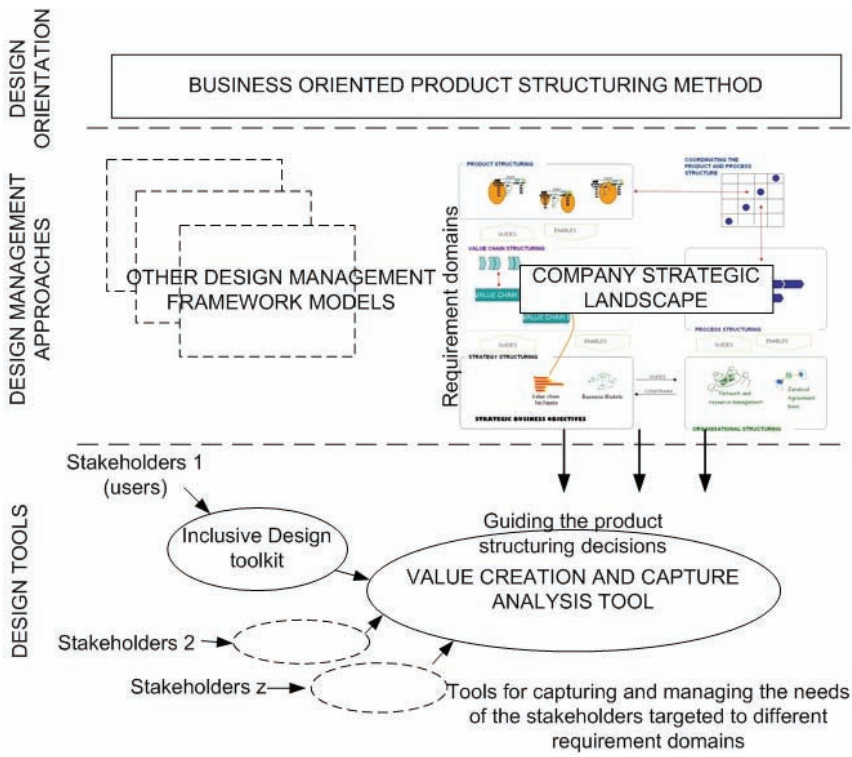

Figure 6. Synthesis: Landscape describing hierarchies between the design approach concepts explored in this paper – explains how Inclusive Design can be utilized as a tool for CSL approach.

Business Oriented Product Structuring Method is a hypernym for the design approaches observing the design requirements arising from business environment. Different stakeholders target varying needs to the product during its-life cycle through the domains described by CSL. Company Strategic Landscape is a framework method regarding all the domains affecting to product structure and their connections for defining the right kind of product structure. VCCA is a tool for capturing the needs targeted to design and guiding product structuring decisions. It brings out the reasons and effects of design decisions. Inclusive Design toolkit provides one of the tools for capturing and managing the needs that certain stakeholders target to product structure through different domains.

Strengthening the end user orientation in CSL approach by applying Inclusive Design toolkit the life-cycle value creation of the design can be improved by making it more functional, usable and desirable to the end user (figure 7).

Figure 7. Benefit for applying Inclusive Design with CSL design management approach [8]

By embedding the Inclusive Design thinking to CSL design framework we can result more user centered and widely applicable products. Improved market awareness and understanding of end user capabilities, if they are private people or companies who aim to use the product, brings an important consolidation to VCCA. If the end user needs are not recognized in early design phase the product might unnecessarily exclude potential users or cause usability problems and weaken its chances for a market success.

REFERENCES

[1] [Hubka 1984/88] Hubka, Vladimir, Eder Ernst (88 edition), ”Theory of Technical Systems”, ISBN 3-540-17451-6, Springer-Verlag, Berlin, 1988, first published in German ”Theorie Technisher Systeme”, Springer 1984.

[2] Lehtonen T.,2007. “Designing modular product architecture in the new product development.” Doctoral Dissertation, Tampere, TUT, 2007.

[3] Erixon, G., 1998. “Modular Function Deployment – A Method for Product Modularisation”, Kungliga Tekniska Högskolan, Stockholm, 1998.

[4] Laudon K, Laudon J., “Management Information Systems.” Eigth edition, Prentice Hall, New Jersey, 2009, 2007.

[5] Andreasen M. M., Olesen J., 1990 “The concept of dispositions”, Journal of Engineering Design Vol 1, No 1, 1990, Carfax publishing company, Oxfordshire, UK.

[6] Cantamessa M., Rafele C., 2002. ”Modular products and product modularity - Implications for the management of innovation and for new product development”, Proceedings of Design Conference Design 2002, Dubrovnik, 2002, pp. 29-36.

[7] Umeda Y., Nonomura A., Tomiyama T., ”Study on lifecycle design for the post mass production paradigm”, Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 14, Cambridge University Press, 2000, pp. 149-161.

[8] Clarckson J., Coleman R., Hosking I., Waller S., “Inclusive design toolkit”. 2007. Kall Kwik Cambridge. Cambridge 2007.

[9] Juuti T., 2008, “Design Management of Products with Variability and Commonality.”Doctoral dissertation, Tampere, TUT, 2008.

[10] Keates, Simeon L., Clarkson, P. John, Countering Design Exclusion. An introduction to inclusive design. 2003, ISBN: 978-1-85233-769-8. XIV, 227 p. 2003.

[11] Langdon P., Lewis T., Clarkson J. The effects of prior experience on the use of consumer products. Published online 14 August 2007. Springer-Verlag. 2007

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