PRODUCT COMPLEXITY REDUCTION
– NOT ONLY A STRATEGY ISSUE

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ABSTRACT

Introduction: Nowadays many industrial organisations are dealing with more and more complex products to comply with customer demands. This has the positive effects of increasing the market share and enabling manufacturers to enforce higher product prices. However, increased product complexity comprises some drawbacks as well. Most important to mention are increased product cost but also quality problems and prolonged lead times (Galsworth, 1994). Due to those drawbacks there have been made several attempts to reduce product complexity which were more or less successful (Bohne, 1998; Bliss, 2000). However, nowhere it is mentioned that to enable successful product complexity reduction an according organisational culture has to be developed. That is, to be able to implement an innovative product complexity reduction strategy it is important to create a company culture which fits and supports this strategy. If these two issues are in line with each other the chances for realising this strategy are maximised. Therefore, this paper combines classic approaches of product complexity reduction with the cultural aspects necessary inside the organisation to be successful. The result is a comprehensive guideline for fruitful product complexity reduction efforts.

Purpose: It shall be shown how plans and strategies for product complexity reduction can be derived by analysing the actual product structure. Further, it should be pointed out which kind of organisational culture is necessary to realise these strategies. By doing so, a guideline for product complexity reduction will be created including plans for product complexity reduction efforts as well as how an appropriate and supporting company culture should look like. The result is a comprehensive guideline for successful product complexity reduction efforts.

Research method: In this conceptual paper a method is introduced to analyse the actual product structure according to necessary product complexity which is creating customer benefits and the non-necessary product complexity which is not directly linked to increased customer benefits. Based on this analysis plans and strategies can be derived to reduce non-necessary product complexity. Finally, it will be illustrated that a specific organisational culture is needed to reduce product complexity in a meaningful way.

Results/conclusions: Analysing the product structure according to necessary and non-necessary product complexity enables an organisation to develop strategies and plans to reduce product complexity while at the same time keeping customer benefits constant. To be able to divide product complexity into necessary and non-necessary complexity an understanding has to be developed how product complexity is creating customer benefits and what the impacts of product complexity throughout the organisation are. That is, a broad integrated approach is necessary to gather this information. Therefore a cross functional or system focused organisational culture is necessary.

Keywords: product complexity, organisational culture, system focus, cross-functionality

INTRODUCTION

Product complexity regarded from two perspectives. On the one hand it is necessary to fulfil the requirements of a complex market (Bohne, 1998). That is, if customers request an advanced product with a lot features and at the same time a high degree of product variety it is necessary to develop a complex product. This kind of product complexity is necessary to create a product which the customers value. On the other hand product complexity can be negative (Child, Diederichs et al., 1991; Bliss, 2000). This is the case when the degree of product complexity exceeds the degree of necessary complexity which is demanded by the market. In this situation unnecessary complexity is created without adding additional customer value. Nowadays products become more and more complex and several companies loose control over the degree of product complexity (Bliss, 2000). That is, the degree of product complexity does not orient towards the complexity which is demanded by the market any longer, moreover, without an identifiable reason it is growing unintentionally. To be able to assess whether one is dealing with necessary or unnecessary product complexity it is essential to be able to measure product complexity. When looking at the literature on product complexity one can observe that there have been several approaches undertaken to measure product complexity (Benton and Srivastava, 1993), (Guide, Srivastava et al., 1997), (Sum, Oon-Sen Png et al., 1993). The measures of product complexity are used to research the impacts of product complexity on e.g. lot sizing, inventory stock levels or production process complexity. The general notion is that the less product complexity is created the better it is for the organization's operations. This is supported by empirical evidence e.g. Sum, Oon-Sen Png et al.(1993) showed that less product complexity results in lower inventory levels, less complex material flows and lower production costs.

Since product complexity is generally regarded as having negative impacts on the company's operations it should be reduced to the amount of necessary product complexity which is needed to fulfil market demands. However, it appears that some organisations loose control on the degree of product complexity. Therefore, the purpose of this paper is to investigate how the degree of product complexity could be controlled and kept at a reasonable level.

PRODUCT COMPLEXITY REVIEW AND FRAMEWORK

Product complexity is a widely used term and so far there is no generally accepted definition of it. This is expressed in the following citation. "Choice of measures of product complexity depends of the objectives of the analysis, the product and production system, and in some case, the accessibility of data."(Ding, Sun et al., 2007). This refers to the fact that many papers dealing with product complexity create their own, "customised" definition of product complexity. That is, product complexity can be researched according to its implications on lot sizing (Sum, Oon-Sen Png et al., 1993). Other authors researched the impacts of product complexity on the supply chain (Novak and Eppinger, 2001). Kotteaku, Laios et al. (1995) estimated the impacts of product complexity on the purchasing activities. All the above mentioned authors created their own customised product complexity definition. This paper differs from the mentioned examples in the following way. It is tried to develop a general description of product complexity to be able to offer a general product complexity reduction guideline. That is, this guideline should be applicable for different products in a various of industries.

Product complexity in its context

Before a more detailed description of product complexity is given product complexity has to be positioned in its context. That is, beside product complexity there are several other kinds of complexity in the production system? Bliss (2000) identified four different kinds of complexity. These are customer portfolio complexity, program complexity, product complexity and process complexity. The latter one, process complexity, can be further divided into production program complexity, organization complexity and complexity of the manufacturing system. All kinds of product complexity can be summarized under the term organizational complexity.

Putting product complexity into its context of organizational complexity with its different kinds of complexity illustrated by Bliss (2000) is not sufficient. What is missing are the relations of the different kinds of complexity to each other. This shortcoming is overcome by the introduction of the concept of the degree of coupling (Bohne, 1998). In this approach complexity in general is interpreted as multidimensional variety. Other than Bliss (2000) Bohne (1998) defines organizational complexity not as a set of different kinds of complexities but as as different kinds of varieties e.g. market and customer variety, material variety or process variety. Bohne (1998) connects the different kinds of variety (complexity) to each other according to their causal relationships. In other words, organization complexity is propagating through the organization. This chain of relationships begins with market and customer variety which leads to a high variety offering. This results in a high degree of material variety. To handle a high variety offering and high material variety process complexity (process variety) has to be increased. The final result is high resource variety and supplier variety. The chain of causal relationships is illustrated in figure 1. For the remaining part of the paper high variety offering and material variety is interpreted as product complexity. To underline this deviation from Bohne (1998) the two kinds of variety are shaded grey. This will also be the focus area in this paper. To enable further discussion two important issues have to be pointed out. Firstly, product complexity results from market and customer variety. Market and customer variety is an exogenous variable which imports complexity into an organization (Bliss, 2000). Since it is an exogenous variable this variety is regarded as fixed in the remainder of this paper. The second issue to point out is that several other kinds of complexity are a result of product complexity e.g. process, resource and supplier complexity, see figure 1. The concept of degree of coupling is basically

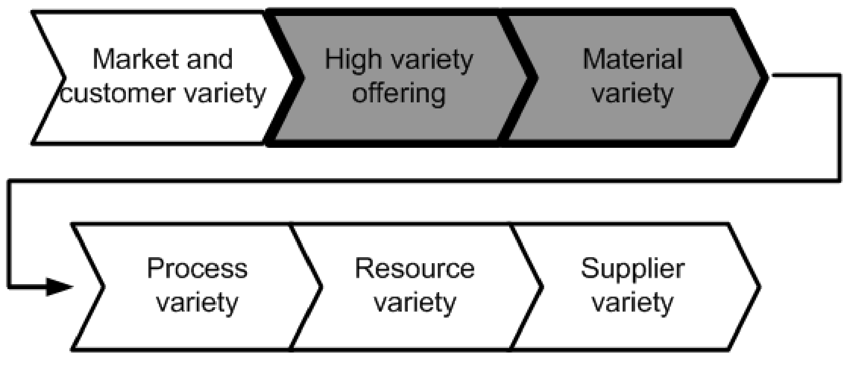

Figure 1: Causal relations between complexity types (Bohne, 1998)

saying that the different kinds of variety are not coupled fully. That is, there are several possibilities to decrease the coupling between the different kinds of variety. This paper now addresses the interfaces which product complexity has towards the market and customer variety and the following kinds of variety, see figure 1. It will be pointed out that product complexity can be adapted to inhibit the total propagation of external market and customer variety throughout the whole organization. The underlying rationale for doing that is to reduce the overall organizational complexity.

Product complexity based on complexity dimensions

As described above there is a big amount of different definitions of product complexity and no generally accepted description. That means that the main challenge in the definition of product complexity will be to develop a generally applicable description of product complexity. Therefore, during the literature study the different concepts were scanned according to two criteria. First, the product complexity dimension had to be general and not only applicable to one product or one group of products. Second, the measures for product complexity had to be differentiated from measures of other kinds of complexity e.g. process complexity or resource complexity. The results of the literature review are shown in table I.

Product complexity dimension	**Authors**
no. of relations between elements	(Patzak, 1982); (Barclay and Dann, 2000); (Bliss, 2000; Novak and Eppinger, 2001)
type of relations between elements	(Patzak, 1982); (Barclay and Dann, 2000)
no. of elements/component/parts	(Patzak, 1982); (Barclay and Dann, 2000); (Novak and Eppinger, 2001);(Sum, Oon-Sen Png et al., 1993); (Guide, Srivastava et al., 1997)
type of elements	(Patzak, 1982)
no. of technologies involved	(Barclay and Dann, 2000)
product breadth/no. of product variants	(Benton and Srivastava, 1993); (Ding, Sun et al., 2007)
extent of embedded software	(Hobday, 1998)
model mix complexity	(MacDuffie, Sethuraman et al., 1996)
parts complexity	(MacDuffie, Sethuraman et al., 1996)
option content	(MacDuffie, Sethuraman et al., 1996)
option variability	(MacDuffie, Sethuraman et al., 1996)
no. of attribute	(Ding, Sun et al., 2007)
no. of attribute values	(Ding, Sun et al., 2007)
no. of unique parts per attribute	(Ding, Sun et al., 2007)
no. of moving parts	(Banker, Datar et al., 1990)

Table I: Product complexity dimensions

Product complexity as a relative element

The following question to be answered is how to apply these product complexity measures. When addressing this question two things have to be kept in mind. First, they have to be measured and displayed in a way that they work as a guideline e.g. for product development engineers and that they are generally applicable. Coming to the latter one, different industries have different demands on their products. To take an easy example, what is high degree of product variants in the household appliances industry is probably totally different from a high degree of product variety in the car or truck industry. When comparing different industries with each other this argument seems to be straightforward. However, even in the same industry there are different market segments which vary in their inherent level of product complexity. To sum up, a general accepted definition of product complexity appears to be difficult since it is almost impossible to put absolute values on the different product complexity dimensions which are valid for several different products. To face this problem product complexity can be regarded as a relative element (Guide, Srivastava et al., 1997), (Suh, 2005). Before doing this the difference between “necessary” and “non-necessary” complexity is explained further. According to Bliss (2000) product complexity is partly regarded positive (necessary complexity). That is, to be able to correspond to markets demanding a highly advanced product with several variants which can be customised a complex product has to be developed. In other words, in order to create customer value an according degree of product complexity is necessary. External and internal complexity have to match each other. However, Bliss (2000) further argues that product complexity is also created without creating customer value (non-necessary complexity). These coherences are shown in figure 2. The important implication is that market and customer variety demand internal variety (necessary complexity). However, beside the necessary complexity also non-necessary complexity is created. The important point is that necessary and non-necessary complexity with all its negative impacts influence increase the complexity in other organizational units.

THE CASE COMPANY

The data for this paper has been collected as part of a three-year longitudinal and in-depth research study in a European manufacturing company. Their product development activities are mainly located in Europe, however, this organization has

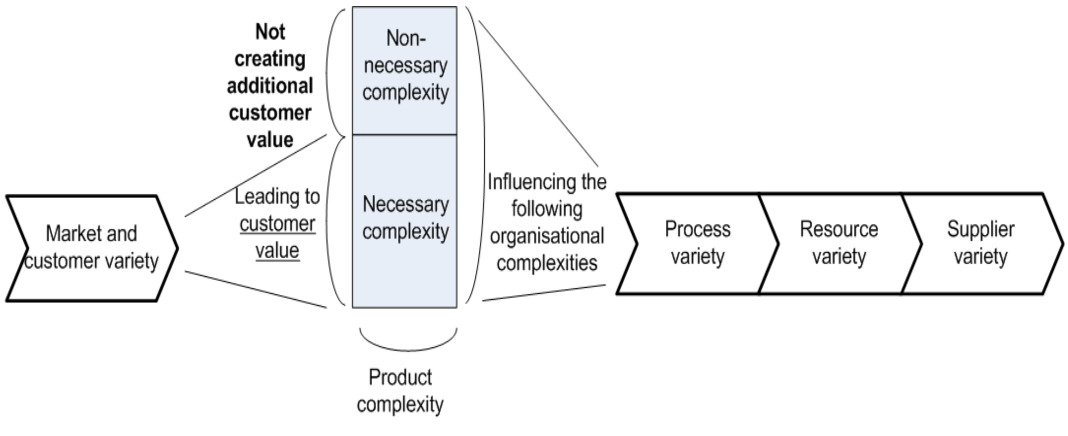

Figure 2: Necessary versus non-necessary product complexity

production facilities all over the world. This longitudinal research study began approximately one and a half years ago, during this time the data has been collected on a regular basis. The reason for conducting this study was to reduce the organizational complexity by introducing a revised platform strategy and modularising the product stronger. Due to the complexity reduction focus of the study and the fact that the product is complex the study offered the opportunity to apply the concept of relative complexity. Further, the product fulfils many of the product complexity dimensions identified in this paper, e.g. it consists of a large number of parts and there are many connections between these parts in the product.

The chosen area of analysis

Investigating the whole product in terms of one, several or all product complexity dimensions would be much too time consuming. Instead, the study focused on the interfaces between the three biggest and most complex units of the product. Firstly, there is the base module and secondly two big modules. Finally, these two units have to be assembled on the base module. That is, we are dealing with two interfaces. Since these modules are complex units and comprise a rather large share of the product only the connecting media between these three modules was analyzed, that is, the number of interconnections. More precise, it was focused on the number of potential interface connection variants. Hereby, the connections which were supposed to have the most severe impact on other kinds of complexity throughout the organization were analyzed.

These were for the Base module – Module 1 interface:

- Fuel lines
- Water to power steering system
- Electrical signal
- Electrical ground
- Electrical power
- Hydraulics to power steering

And for the Base module – Module 2 interface:

- Pneumatics
- Clutch hydraulic
- Fuel
- Gear shift cable
- A/C pipe
- Water pipe
- Fuel hose
- Electrical signal
- Electrical ground
- Electrical power

The analysis was done as follows. Firstly, the actual product structure was mapped in terms of connections between the modules. For each connection the number of connection variants was determined. Than a realization of the revised platform and at the same time a stronger degree of modularity was assumed. Under this scenario it was assessed to which degree the amount of connection variants between these modules could be reduced.

ANALYSIS

In this paper the concept of relative complexity is applied to assess the potential of product complexity reduction. Further, an approach will be proposed which supports a successful product complexity reduction strategy.

Product complexity as a relative element

The idea of a relative complexity measure works as follows. First the actual value of one complexity dimensions in table I is determined (necessary and non-necessary complexity). Than an optimal product structure, which only creates customer value, is assumed. Subsequently the value for the chosen complexity dimension is assessed again in this ideal scenario. That is, how much complexity is necessary to create the expected customer value (only necessary complexity). Finally, necessary complexity and actual complexity are set into relation to each other:

Relative complexity = necessary complexity / overall complexity (1)

A value below one would mean that there is more product complexity than which is necessary to create the expected customer value. The higher the value for relative complexity the lower is the amount of unnecessary product complexity which is not creating any customer value. If the value for relative complexity is one one is facing the ideal situation of no non-necessary complexity.
It has to be mentioned that the reduction potential of the media connection variety has been assessed based on the assumption that the customer value is not increased or decreased. That is, the difference in the number of media connection variants in the actual state and the in the optimised product state can be regarded as non value adding for the customer. The results of the data gathering are shown in the tables in appendix 1 and 2. The number of connection variants for each interface was added and applied to the above introduced equation 1.

$$relative\_complexity = \frac{necessary\_media}{acutal\_media}$$
$$= \frac{20+4+100+1+1+1+2+400+5+1}{65+20+500+2+280+4+3+10+800+10+200+20+30+110+7+20+40}$$
$$= \frac{535}{2121} = 0{,}252 \approx 25{,}2\%$$

In this example of the three modules the necessary product complexity in terms of number of connections variants between elements is 0,252 times as big as the actual product complexity. That is, only 25,2% of the product complexity in terms of connections between the elements is necessary to create the delivered customer value. The relative complexity measure provides a clear guideline towards product development to reduce the number of connections between the different modules by applying a higher degree of modularity.
This calculation can be done for several product complexity dimensions. This provides product developers with an accurate overview over the product structure,

that is, how much of the complexity is actually creating customer value and how much complexity has been created unnecessarily.

The result is rather impressive and states very clearly what the actual situation with regards to product complexity is all about. Only 25,2 % of the product's complexity in terms of number of connection variants is necessary. How is it possible that an organization is so far away from the optimal status. Are there some mechanisms which lead to higher product complexity? In the case company e.g. business cases are applied for different kinds of product development decisions. These are applied in a way that they focus on a rather small part of the product and that only quantifiable impacts are considered. The result is that impacts of product development decisions in the rest of the product are not considered. Further only claearly quantifiable impacts are considered in the business cases while the costs of complexity are mostly hidden (Child, Diederichs et al., 1991). The result is that impacts of product complexity are not included in the business cases. This low system focus leads to an externalisation of cost. That is, product development decisions are made without considering all its consequences. As a result, product complexity grows. Another example is the high degree of functional differentiation with a low level of cross-functional communication at the same time. This further intensifies the problem of assessing the impacts of product development decisions in other functional units. It was also observed that overall targets were broken down in a way that two functional units with mutual task dependencies developed contradicting behaviors which inhibit the optimization of the overall goal.

If it's clearly shown that one is so far away from optimal situation one could assume that it is very easy to take the appropriate action, according to the expression:"Ok, we have a problem, let's do something about it!" However, it has to be made clear that this is not that easy. The right question to ask here is: Although all people involved in product design have been given their best over the last decades we did end up with this situation. What is the underlying reason? An answer to this is given by Schein (1985). He is stating that one has to understand the company culture to understand the mysterious and seemingly irrational things that are going on in human systems. That implies that a specific company culture leads to situations like this one. The other way round this means, if a mysterious or seemingly irrational organizational behaviour should be changed one has to include the culture. It is not a seldom phenomenon that companies fail to implement strategies which make sense from a financial or like in this case product point of view because the demanded company culture is too far out of line with the company's culture (Schein, 1985). This is in line with Martenssen and Dahlgaard (1999). Their concept of the extended PDSA loop shows this interconnection in between an intended strategy and a necessary culture to realise this strategy. The concept of the extended PDSA loop basically states that after a company has formulated its strategies and plans and discovers that it does not have the supporting company culture for realising these strategies the culture has to be adapted as well. Several authors agree that that strategies, to be implemented or already existent, need to be backed by an according culture (Deal and Kennedy, 1982; Kahn, 1996).

To sum up, it has been shown that the degree of product complexity is rather high in the case company. Further it has been argued that a newly introduced strategy demand a supporting cultures. The next step is to provide the necessary supporting culture to facilitate the realisation of product complexity reduction.

System focused company culture

When we are talking about a specific culture providing an appropriate environment for product complexity reduction we are entering a rather untouched field. Nevertheless, when looking at the underlying reasons of unnecessary complexity several characteristics of a potential environment come to the fore.

Further it has to be pointed out that product complexity is a result of the product development process (Banker, Datar et al., 1990). While this statement is rather straightforward it has important implications for the degree of product complexity. That is, the product developers decide upon the degree of product complexity. According to Bohne (1998) product developers are well aware of market demands. However, they are not fully aware of the cost and complexity implications of their design choices. Bohne (1998) has identified a transparency deficit regarding product complexity. That is, with nowadays accounting systems the real cost impacts of product complexity can not be traced. Accounting systems allocate product cost according to material cost and man hours. Further, they have a strong focus on the direct processes and therefore neglect the indirect processes. This leads to the following problems. Firstly, it is difficult to assess the complexity costs of design choices in the design stage. Consequently it is difficult to compare product complexity design choices. It can be summarised that the target system for product developers is open in terms of product complexity. Since nowadays accounting systems are not of much help for the product developers in assessing the implications of their design choices one can conclude that there are other means needed to make product developers aware of the implications of their design choices.

To face the described problem of the externalisation of costs, that is, the disregard of a share of the costs, a system focused decision making is necessary. That implies that all effects of the decisions regarding product complexity are taken into consideration (Bohne, 1998; Bliss, 2000). Therefore the author is calling for a system focused company culture. The situation is illustrated in figure 3. It is shown how product complexity is propagating through the system and how feedback with regards of the effects of product complexity should be fed back and made available.

Here Iansiti (1995) provides an appropriate approach. He calls his concept "system focused organization". Since this concept was originally created to evaluate the interaction between novel technical approaches and the existing environment it is

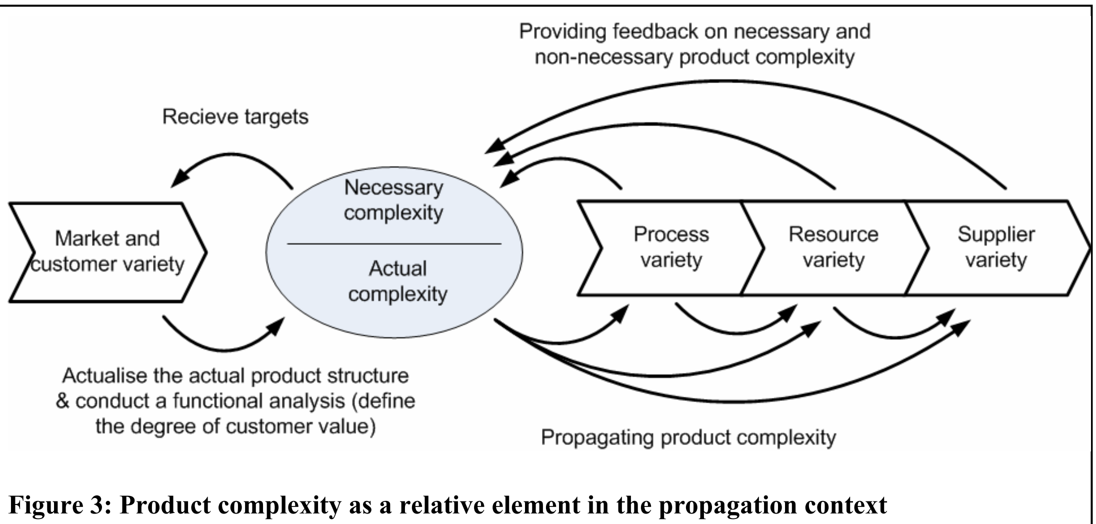

Figure 3: Product complexity as a relative element in the propagation context

applicable to “connect” product developers with the environment which they are affecting.
System focused organizations can be characterised in the following way. “System focused organizations emphasize an extensive and proactive analysis of the impact of individual design possibilities on the integrated properties of the entire network of design decisions.” (Iansiti, 1995). In our case this definition is adapted in way that the focus is on implications of individual design possibilities on the other organizational complexities. If this difference in the set-up is taken into consideration the original definition of system focused organizations can be redefined accordingly. That is, a system focused organization:

- dedicates adequate resources to integrated decision making.
- focuses on the early generation of knowledge of the potential impact of individual decision on the broad characteristics of the existing product and production system
- retains past knowledge of integrated decision making.

Further Iansiti (1995) underlines that a broader problem solving approach is needed to gather all the relevant knowledge needed. Therefore, he argues for cross-functional teams. By doing, so a broader base of disciplinary knowledge is gathered. All these actions are assumed to increase the development performance in terms of being aware of all the implications of development design choices. The approach of a system focused organization is illustrated in figure 4.
Having a strong system focus and problem solving breath are to ways to increase the product development performance in terms of the reduced product complexity level. However, this is not the whole story. The underlying reason is that culture goes deeper than this. Culture can be seen in three layers (Schein, 1985). The first and most superficial layer is what Schein (1985) calls artifacts and creations. Below this first

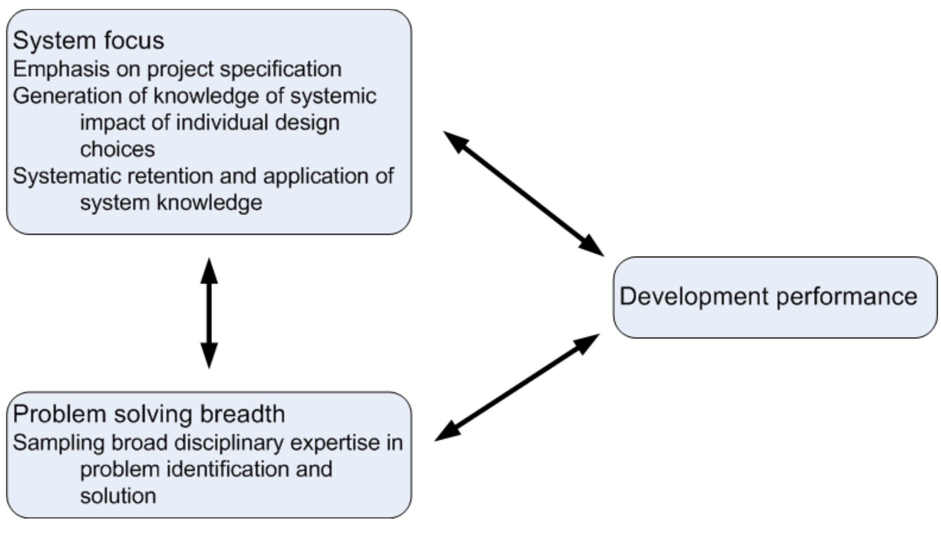

Figure 4: The system focused organization (Iansiti, 1995)

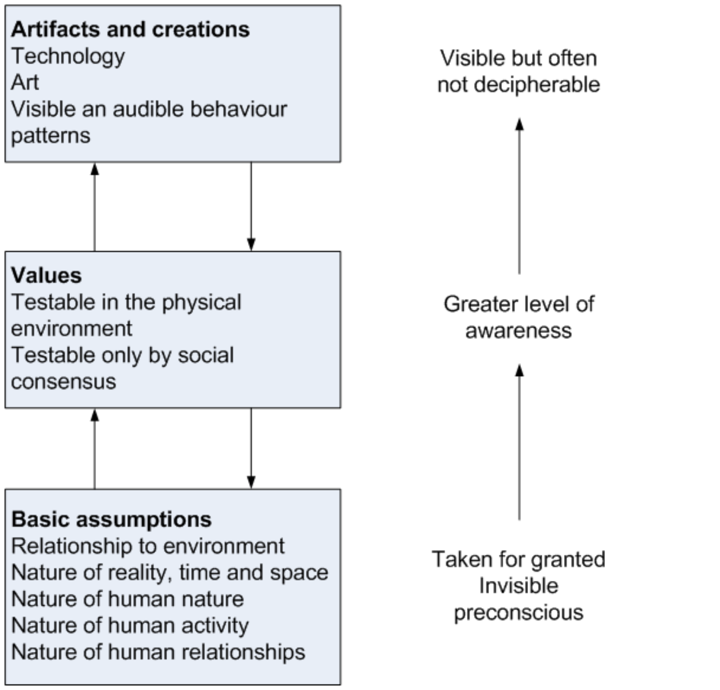

Figure 5: Three layers of organizational culture (Schein, 1985)

layer one can find values of the people who are part of the group that forms the culture. Below these values one can find basic assumptions. Schein's (1985) definition of culture is illustrated in figure 5. Artifacts and creations are the most visible layer of the organizational culture, that is, its constructed physical and social environment. It includes the technological output of a group as well as its overt behaviour patterns. Although insiders are not necessarily aware of the artifacts one can always observe them. What Iansiti (1995) characterises as a system focused organization, system focus and problem solving breath, can be categorised as artifacts. According to Schein (1985) it is easy to observe these artifacts. So far the first layer of the demanded organizational culture has already been defined. However, the difficult and important part is to understand what these artefacts mean and what deeper patterns they reflect. This is done by analyzing the central values. These are day-to-day operating principles of the group members of a culture which guide their behaviour. Other authors describe values as the basic concepts and beliefs of an organization which form the heart of the corporate culture (Deal and Kennedy, 1982). Strong cultures have rich and complex systems of values which are shared by the members of the group. While values can be questioned, debated and challenged basic assumptions are different in terms of that they are so much taken for granted that they are nonconfrontable and nondebatable (Schein, 1985). Accordingly, there is little variation inside a group when it comes to the basic assumptions and behaviour based on any other premise would be inconceivable. Basic assumptions are on the one hand more general than values but on the other hand more ultimate. Often they have been dropped out of consciousness and are treated as reality. Schein (1985) categories the basic assumptions into five categories as illustrated in figure 5.

According to Schein (1985) it is not enough to define culture only by the artifacts. To provide the full picture of an organisation's culture assumptions and values have to be deciphered as well. The reason is that artifacts, are dependent or built upon the actual

assumptions and values. In case a strategy with the accordant artfacts is too far out of line with the existing values and basic assumptions it is highly probable that the strategy will not be realised.
In other words, if a strategy for product complexity reduction with its cultural artefacts of a system focused organization and broad problem solving is to be implemented the values of the group members as well as their basic assumptions have to be in line with a product complexity reduction strategy as well. For that reason the values and basic assumptions which are in line with a system focused organization and broad problem solving will be outlined in the remainder. Since it has not been done before to discuss a supporting culture for product complexity reduction the values and assumptions can only be derived from the literature dealing with system focus and cross-functionality.

Values

By reading literature dealing with system focus and cross-functionality several values can be deduced. The first value can be derived from the fact that individuals which integrate functional units have to share more ways of thinking and behaviour patterns than the functional managers share with each other (Lawrence and Lorsch, 1967). That means, to integrate an organization other functions' issues have to be acknowledged and understood. Second, functions eventually have to adapt to other functions' needs. Accordingly, Wolff (1985) names as one hinder to bridge R&D with manufacturing that R&D assumes that their responsibilities end when they push their solution through the manufacturing departments door. This implies that demands between R&D and manufacturing should be balanced (Lawrence and Lorsch, 1967). Although it could be extensive or costly for one function to include the needs of another function it is necessary to realise an integrative organization (Walton and Dutton, 1969). In other words, it should be a guiding principle for all functions to make concessions to other functions in order to improve the overall result of the whole system (Gray, 1985). Third, to be able to do these interfunctional adaptations people have to understand that mutual task dependence is the root cause of interunit conflict (Walton and Dutton, 1969). It is one core value to acknowledge mutual task dependencies since they form the basis for coordination and cooperation demands and very important, to understand them. Fourth, to understand mutual task dependencies open and precise communication is at core (Gray, 1985; Wolff, 1985). By doing so unterunit conflict through ignorance is avoided (Walton and Dutton, 1969). Finally, Walton and Dutton (1969) argue that there could be interdepartmental differences in whether to consider measurable or intangible impacts. However, since the costs of complexity are mostly hidden (Child, Diederichs et al., 1991), it is important to also include results which are hard to quantify as well.
To sum up, the values which are necessary to support a system focused view and broad problem solving are:

- Beside the own departmental drivers, issues of the other functions have to be understood and included in the decision making.
- The best for the whole organization is more important than the best for the single business unit
- Mutual task dependencies have to be discovered since they form the basis for coordination and cooperation demand.
- Communication is good since it avoids a conflict through ignorance.
- Impacts which are hard to quantify have to be taken into consideration as well.

Basic assumptions

All cultural values are based on basic assumptions. According to Schein (1985) the real culture are the basic assumptions. That is, the cultural values as well as the artifacts are only manifestations of the organizational culture. The question to answer now is what basic assumptions are necessary in an organisation to enable the artifacts and the values discussed above. The basic assumptions can be derived from the already defined values. While deriving the necessary basic assumptions for a low product complexity culture it turned out that not all the categories of basic assumptions which are shown in figure 5 are affected. The categories of basic assumptions which are relevant for a low product complexity strategy are the following:

- Nature of human relationships
- Nature of human nature
- Nature of reality, time and space

Coming to human relationships there are three basic assumptions which can be derived. First, interdepartmental integration is valuable. It is important that people in an organisation are really convinced that it is worth to invest in integration activities. That is, they should try to understand the issues of other functions and include them in the decision making. Therefore, the necessary basic assumption here is that interdepartmental integration is valuable. Second, The systemic view should be taken. This issue is closely related to the fact that organisations would like to achieve their overall goal as good as possible. Therefore, perhaps functional interests have to stand back. Since it is hard to disregard the own functional interests in favour for the overall performance goal there should be a basic assumptions that a systemic view should be taken, that is, effects in the whole organisation should be taken into consideration. Third, mutual task dependence has to be discovered. As already pointed out, mutual task dependencies are at core in integration activities. Since they form the basis for coordination and communication demands a strong focus should be put on the discovery and the understanding of mutual task dependencies. When it comes to the nature of human nature the necessary underlying basic assumption is that humans are communicative, open, trustful and friendly. If an organisation really wants to make mutual interdependencies visible and understand them it demands open communication. Further, there has to be a trustful atmosphere to share all relevant information interfunctionally. Finally, a very important assumption when it comes to nature of reality, time and space is that intangible effects must be acknowledged. As already mentioned, effects and costs of complexity are mostly hidden, that is, they are hard to quantify. However, this does not mean that they are not severe or important. Therefore, these costs have to be taken into consideration in the decision making.

The complete culture to support product complexity reduction efforts in terms of artifacts, values and basic assumptions is summarised in table II.

Cultural Level	Content
Artefact	System focused organization
	Broad problem solving (cross-functional way of working)
Values	Beside the own departmental drivers, issues of the other functions have to be understood and included in the decision making.
	The best for the whole organization is more important than the best for the single business unit
	Mutual task dependencies have to be discovered since they form the basis for coordination and cooperation demand.
	Communication is good since it avoids a conflict through ignorance.
	Impacts which are hard to quantify has to be taken into consideration as well.
Basic assumptions	Interdepartmental integration is valuable.
	The systemic view is the one to take.
	Mutual task dependency has to be discovered.
	Humans are communicative, open, trustful and friendly.
	Intangible effects must be acknowledged.

Table II: Values and basic assumptions to support a product complexity reduction strategy

CONCLUSIONS AND MANAGERIAL IMPLICATIONS

The contribution of this paper is twofold. First, it has been pointed out that a product complexity reduction strategy demands a specific integrative company culture including system focus and broad problem solving. By following a product complexity reduction strategy and at the same time having a supporting company culture at hand product developers are provided with a holistic view. This holistic view implies that developers have information on all effects and cost impacts of a potential design decision. This means that they have more information at hand and therefore are set into the position to design a better product in terms of the overall goals of the organisation. It was pointed out that this culture should put a high emphasis on system focus and broad problem solving. Second, instead of only providing a superficial description of the company the necessary underlying patterns were identified and illustrated. Managers who are applying a product complexity reduction strategy are provided important information to reduce product complexity successfully and durably. By understanding the necessary underlying values and basic assumptions the risk of failure while implementing product complexity reduction strategies is reduced substantially. That implies, to reduce product complexity managers also have to manage the company culture. They have to shape the values according to the product complexity reduction strategy. That is, they have to create a rich and logically consistent system of values which is supporting the strategy. Further they have to assure that these values are shared among the members of the organization. If the values are managed successfully and constantly the first successes will be realized. Members of the organization will start to accept and embrace the values and develop the accordant basic assumptions. At this point a supporting culture to reduce product complexity is implemented. Only with an appropriate culture at hand the implementation of a product complexity reduction strategy is promising.

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APPENDIX

Appendix 1: Potential interface connection variants for chosen connection components for the
base module – module 1 interface.

Base module – Module 1		
Media:	**Number of variants**	
	Actual Complexity	**Necessary Complexity**
Pneumatics	65	20
Hydraulics to power steering	20	4
Electrical power	500	100
Electrical ground	2	1
Electrical signal (in thousand)	280	1
Water to power steering system	4	0
Fuel lines	3	1

Appendix 2: Potential interface connection variants for chosen connection components for the
base module – module 2 interface.

Base module – Module 2		
Media:	**Number of variants**	
	Actual Complexity	**Necessary Complexity**
Pneumatics (in thousand)	10	2
Electrical power	800	400
Electrical ground	10	5
Electrical signal (in thousand)	200	1
Fuel hose	20	0
Water pipe	30	0
A/C pipe	110	0
Gear shift cable	7	0
Fuel	20	0
Clutch hydraulic	40	0