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REDUCING THE TIME DEPENDENT COMPLEXITY IN ORGANIZATIONAL SYSTEMS USING THE CONCEPT OF FUNCTIONAL PERIODICITY

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ABSTRACT

Economic growth and sustainable value creation are a company's most important long-term targets. However, practical experience shows that large structures notoriously suffer from efficiency losses due to increasing organizational complexity and bureaucracy. To realize a profitable growth, companies have to be good in handling their internal diseconomies caused by the increased complexity of large organizations [Matt, 2007/b]. This hypothesis is confirmed by a study of the St. Gallen Centre of Organizational Excellence (CORE) in which 300 large European enterprises were analyzed within a period of 10 years [Gomez et al., 2007]. The results of the research show: the central challenge for profitable growth consists in a company's ability to continuously improve its organization in efficiency and flexibility. Thus, one of the major challenges is to select an organizational system configuration that promotes a sustainable business growth and is easy to operate and manage. In this paper a concept for reducing the complexity of an organizational system is discussed in order to maintain a company's high system efficiency as a success factor for sustainable growth. Starting from the Axiomatic Design based complexity theory a procedure is presented that helps system designers and operations managers not only to design organizational systems with low or zero time-independent complexity, but also to re-initialize the once designed organizational system before time-dependent combinatorial complexity drives it to fail, i.e. to lose its competitiveness due to heavy losses in efficiency. A central aspect is the identification of a functional periodicity. With the help of a practical example the concept of the organizational periodicity is explained, a generally applicable cycle with four phases that is adapted to the individual company's situation by compressing or stretching the sinus curve over the timeline.

Keywords: complexity, organizational systems, periodicity.

1 INTRODUCTION

Numerous authors have emphasized the importance of an organization's structure and its relationship with an organization's size, strategy and environment [Miller, 1986; Mintzberg, 1989]. An organization can achieve a maximum performance if its structure matches the rate of change in its environments [Burns and Stalker, 1994]. In this context, organisational design plays an increasingly important role [Handy, 1993; Pascale et. al., 2000]. Thus, organizational structure and the underlying design principles can be considered a key factor for a company's successful and sustainable development within a turbulent environment.

The more diverse the activities, occupations, functions and hierarchical levels of an organization, the more complex it is [Banner 1995]. Tosi et al. [1994] explain: "There are more coordination and control problems in more complex organizations because there are more task activities to perform, and there are alternative ways to design relationships. Complexity typically is greater in larger organizations."

This problem cannot be solved with the traditional models based on mechanistic systems [Handy, 1990]. Thus, new paradigms are needed to replace the rigidity of traditional organizational structures [Mabey et al., 2001]. The analysis of the existing complexity theory based approaches shows first attempts to overcome increasing organizational complexity in growing structures that are embedded in turbulent environments [Hunter 2002; Galbraith et al. 2002; Shelton 2002]. All of them basically use self organizing principles to tackle the emerging organizational problems related to a time-dependent complexity increase. This way, they try to solve the complexity problems in the "physical domain" [Suh, 2005] by a self-organizing interaction between different agents in a network. However, "complexity problems can be difficultly solved in the physical domain, because every change of the elements and their relationships aiming at the reduction of the system's complexity might influence the overall system's behaviour in an uncontrollable way due to the system designer's lack of understanding of the system's architecture" [Matt 2007/a, p. 866].

But what exactly is complexity? Is there a common understanding or definition? A general definition of complexity is that a complex system is one, which has a large number of elements, whose relationships are not simple [Simon, 1967]. These variables, namely number, dissimilitude and states' variety of the system elements and relationships, enable one to make the distinction between static and dynamic complexity. Whereas static complexity describes the system structure at a defined point in time, dynamic complexity represents the change of system configuration in the course of time [Blecker et al., 2004]. When both complexities are low, then the system is simple; when both complexities are high, then the system is said to be extremely complex [Ulrich and Probst, 1988]. Starting from these definitions, every approach aiming at the reduction of a system's complexity consequently focuses on the redesign of the system elements and their relationships.

According to these definitions, complexity in an organizational system is determined by the uncertainty in achieving the system's functional requirements and is caused by two factors [Suh, 2005]: by a time-independent poor design that causes a system-inherent low efficiency, and by a time-dependent reduction of system performance due to system deterioration or to market or technology changes. Thus, there are two general ways to attack the problems associated with complex systems. The first is to simplify them, the second to control them. Leanness is about the former in that it advocates waste removal and simplification [Womack and Jones, 2003]. It aims at the complexity reduction of a system at a certain point in time. Thus, system simplification is about eliminating or reducing the time-independent complexity of a system. Changeability is the ability to transform and adapt an organizational system to new circumstances caused by market or environmental turbulences. Thus, complexity control is associated with the elimination or reduction of a system's time-dependent complexity.

2 PROPOSED MODEL

For the systematic complexity reduction in organizational systems, a model is proposed basing on the principles of Axiomatic Design (AD).

The AD world consists of four domains: customer, functional, physical and process. Through an iterative process called zigzagging, the design process converts customer's needs (CNs) into Functional Requirements (FRs) and constraints (Cs), which in turn are embodied into Design Parameters (DPs). DPs determine the Process Variables (PVs). The decomposition process starts with the decomposition of the overall functional requirement – in practice this should correspond to the top system requirement. Before decomposing to a lower level, the DPs must be determined for that level in the physical domain [Suh, 2001].

The FRs and DPs are represented by vectors, their relationship by an n-dimensional matrix [DM]:

$$\{FR\} = [DM]\ \{DP\}$$

As previously outlined, the reduction of the time-independent system complexity is about simplifying a (static) system's design. For this, AD provides two Axioms [Suh, 2001]:

Axiom 1: Maintain the independence of the functional requirements.

Axiom 2: Minimize the information content of the design.

In the special case of a one-to-one direct relationship between FRs and DPs, this matrix is reduced to a purely diagonal matrix which guarantees that every single DP just fulfils one FR. In an ideal system design, these elements are autonomous, they have no interrelations. Such a design is called an uncoupled design. The off-diagonal elements can be represented by arrows. They show that the fulfilment of the diagonal element at the start of the arrow influences the elements at the end of the arrow. The worst case is a circular independence. This is the case in a coupled design and it means a bad system design [Lee and Jeziorek, 2006]. In the case of a triangular matrix circular independence does not exist and therefore the design might be potentially good, although not an ideal design. This case is called a decoupled design. It is obvious that it is very difficult or sometimes quite impossible to really obtain an ideal design.

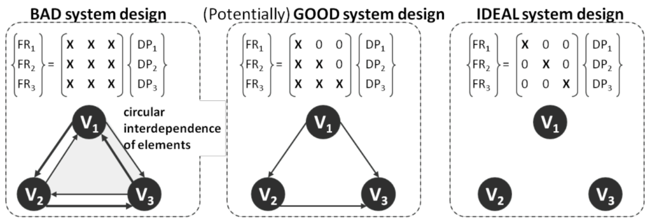

Figure 1. Illustration of the Independence Axiom [Matt, 2007/a; see also: Lee and Jeziorek, 2006].

Time dependent system complexity has its origins in the unpredictability of future events that might change the current system and its respective system range. Thus, it might be defined as system dynamics. According to [Suh, 2005], there are two types of time-dependent complexities:

The first type of time-dependent complexity is called periodic complexity. It only exists in a finite time period, resulting from a limited number of probable combinations. These probable combinations may be partially predicted on the basis of existing experiences with the system or with a very systematic research of possible failure sources. For example, practically all Italian companies in August typically close down for at least two weeks of summer holidays. Foreign customers who do not want to run the risk of going out of stock during this period have to place their orders in advance. This creates a periodic organizational complexity in some Italian companies due to a periodic increase of demand that has to be managed in terms of capacity. However, the periodicity of this events allows to prepare the own organization to timely respond to these complexity drivers.

The second type of time-dependent complexity is called combinatorial complexity. It increases as a function of time proportionally to the time-dependent increasing number of possible combinations of the system's functional requirements and may lead to a chaotic state or even to a system failure. The critical issue with combinatorial complexity is that it is completely unpredictable. For example, some years ago Austrian companies were affected by a catastrophic flash flood and had to close their business for months. However, the development of worst-case scenarios and periodically actualized emergency plans could help to take preventive measures. This way, the unpredictable combinatorial complexity is transformed in to a periodic complexity.

To guarantee sustainable system efficiency, the focus of complexity reduction must be given to the combinatorial complexity. Thus, the time-dependent combinatorial complexity must be changed into a time-dependent periodic complexity by introducing a functional periodicity. If the functional periodicity can be designed in at the design stage, the system will last much longer than other systems. There are

many different types of functional periodicity. The most suitable for the re-initialization of an entire organizational system is organizational periodicity. Any organizational system is influenced by its socioeconomic environment (market and customer behavior, politics, society, etc.). When an organization is not periodically renewed by resetting and reinitializing its functional requirements, it becomes an isolated system that wastes resources [Suh, 2005].
The single steps involved in transforming a system with combinatorial complexity into a system with periodic complexity are demonstrated in the following [Suh, 2005; Matt, 2007/a]:

(1) Determine a set of functions (FRs) that repeats on a periodic (or cyclic) basis.
To create the basic prerequisite for business growth in terms of a maximization of the free cash flow, a company (or an enterprise network) has to generate profitable revenues and to reduce the costs of production and service at the same time. Respectively, the functional requirements for an organizational system can be defined as follows [Matt, 2007/b]:

FR-1 Sell products and/or services successfully
FR-2 Render services competitively
FR-3 Produce efficiently

The design parameters (DPs) mapped by functional requirements are:

DP-1 Efficient sales processes and organization
DP-2 Efficient processes and organization for service performing
DP-3 Efficient production processes and organization

This set of FRs and DPs represents the basic template for the assembly of a good organizational system design. Every company's organizational system can be modelled this way. However, to obtain a good (time-independent) system design, the Independence Axiom has to be fulfilled, i.e. the system design equation must be represented by a diagonal or triangular, n-dimensional matrix. A practical example should help to illustrate this. ABC & CO Inc. (name has been changed) is a small Italian producer of bathroom accessories with about 50 employees. The company has three functional areas: (1) sales and product development, (2) administration and (3) production. Every functional area is managed by one of the three owners of the company. The three areas have some interdependencies and are not completely autonomous. Thus, the matrix is not diagonal and the design cannot be uncoupled. However, it is still triangular and therefore a potentially good design. In fact, the company is successful on markets, and grows profitably over about 5 years. Then, however, the company's development is stagnating due to internal organizational problems; a typical expression of organizational combinatorial complexity.

(2) Identify the DP of the system that may make the system range undergo a combinatorial process.
In this step, those DPs have to be identified that eventually lead to the system's failure because the system range moves outside the design range. DP-1, DP-2 and DP-3 are all potentially subject to time-dependent changes. For example, FR-1 could split off the product development and assign it to another responsibility. As product development can be seen as a technical service, it could be managed autonomously as "service provider". This way, the 3-dimensional matrix becomes a 4-dimensional one. As long as it is at least triangular, the probability of a good organizational development is high. Another possibility would be to decompose FR-1 to the next level of FR-11, FR-12 and so on. Also on the next level, the independence of the FRs has to be maintained in order to provide the organization with a good design.

(3) Transform the combinatorial complexity to a periodic complexity by introducing functional periods.
As the highest level template satisfies the Independence Axiom, a functional period may now be defined that reinitializes the set of identified FRs. According to the Systems Engineering life cycle model (Fig. 2), the trigger point for the system's re-design or disposal is t_2. It starts the re-initialization process. But how can this point be determined? Which are trigger mechanisms of organizational periodicity? As a socioeconomic system, a company is embedded in general economic cycles of upturn and downturn phases. Obviously, every economic sector or even every single company has a different cyclic behavior, but only regarding the timeline. A generally applicable model is the organizational cycle shown in the left part of Fig. 3. It passes always the following four stages: rationalization, innovation, market-offensive and consolidation.

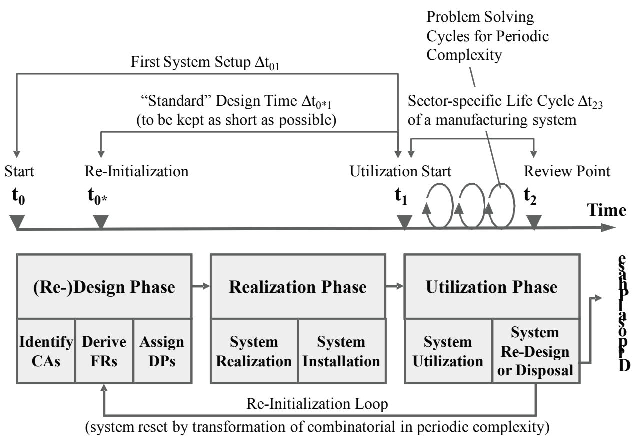

Figure 2. Management of time-dependent complexity in the Systems Engineering life cycle model [Matt, 2007/a].

The company individual adaptation is given by the mapping of this generally applicable cycle along the timeline as a sinus curve. The example in Fig. 3 shows a world economy based [ifo, 2008] sinus curve with a standard interval of 7 to 9 years [Matt 2007/a]. According to the four stages, four trigger points $t_{2\text{-}x}$ may be differentiated. For the present purpose, t_{2_Cons} is the relevant trigger point: it is the periodically returning trigger for organizational change within a company. According to our experiences made with about twenty industrial applications of this model, the sinus interval can vary between 7 to 9 years.

(4) Set the beginning of the cycle of the set of FRs as $t = t_{0*}$.
This step is to determine which FR will be used to establish the beginning of the cycle, that is, $t = t_{0*}$ (see Fig. 2).

(5) Stop the process momentarily.
The need for re-initialization arises from the fact that at $t = t_{0*}$ the state of each FR might not be the same due to a random variation of the system. With the reset, the new values for the FRs can be determined (e.g. a new product mix to be produced, other customer requirements regarding shipping schedules or packaging, etc.).

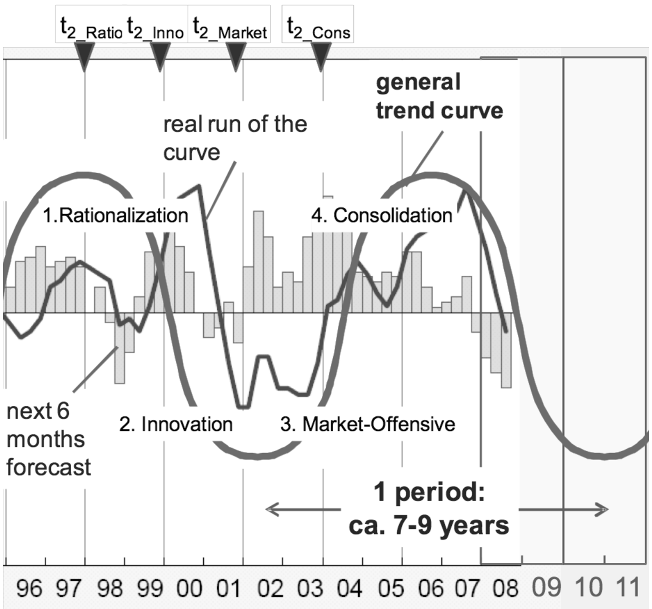

Figure 3. Sinus-Curve-Model for organizational periodicity [ifo, 2008; see also: Matt, 2007/a].

(6) Re-initialize the system.

(7) Determine the best means of satisfying the FRs for the new period.
If the new values for the FRs changed and require an adaptation of the relative DPs, this step is necessary to satisfy the FRs for the next period. For example, a workplace has to be changed to fit a new product's requirements.
(8) Allow the initiation of the next cycle.

3 CONCLUSION

In this paper a concept for reducing the complexity of an organizational system was discussed in order to maintain a company's high system efficiency as a success factor for sustainable growth. Starting from the Axiomatic Design based complexity theory a procedure was presented that helps system designers and operations managers not only to design organizational systems with low or zero time-independent complexity, but also to re-initialize the once designed organizational system before time-dependent combinatorial complexity drives it to fail, i.e. to lose its competitiveness due to heavy losses in efficiency. A central aspect is the identification of a functional periodicity. With the help of a practical example the concept of the organizational periodicity was explained, a generally applicable cycle with four phases that is adapted to the individual company's situation by compressing or stretching the sinus curve over the timeline.

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