AN AD BASED DESIGN AND IMPLEMENTATION APPROACH FOR FRANCHISE-NETWORKS WITH DISTRIBUTED MANUFACTURING UNITS

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ABSTRACT

In recent years franchising as an organizational form has been gaining more and more importance and growing even faster than the overall economy. While we can find many business or juridical approaches and much research about franchising, there is a lack of guidelines for the planning, design and implementation of distributed manufacturing units within franchise networks. This paper presents an Axiomatic Design based concept for the design of a franchise production system with geographically distributed, changeable, scalable as well as replicable manufacturing units. The aim of this research is to derive a complete set of design parameters as well as a systematic approach for the implementation of franchise production systems. To validate and prove the developed concept it has been applied and illustrated in a real case study with an Italian franchise company.

Keywords: Axiomatic Design, production systems, franchising, distributed production.

1 INTRODUCTION

Franchising has lately become more and more important. Under franchising we mean in its broadest sense to build a "best practice" business model and the subsequent transfer of licenses for the replication or duplication of the concept in different target markets [O Monye 1997; Castro *et al.*, 2009]. By franchising, manufacturers can establish facilities in new markets with a minimum of delay and capital outlay [Hayfron *et al.,* 1998].

Besides the traditional pure franchise sales or service license (e.g. Burger King or Subway) franchising is also possible in the form of a production franchise or license to assign the production of goods to a franchisee [Versavel, 2001]. Often, these companies produce not in a central location, but in a decentralized structure, because of the individual customer requests in the various destination countries or especially in the case of food products with a short shelf life. The individuality of products is sometimes given by ethnic, religious or cultural based differences in the markets [Matt and Rauch, 2012]. For the above described reasons franchising models in the form of geographically distributed production franchises or mixed forms (production franchise with simultaneous sales or service franchise) are increasingly used to expand into new markets. This paper puts this special type of production company in focus, which will become increasingly important due to actual and future growth of franchise business models.

A production system should not only produce high quality products at the lowest possible price; it should also quickly adapt to market changes and react to consumer behaviour and trends. Geographically distributed production facilities composed of reconfigurable production systems allow these quick adjustments of production capacity and functionality with respect to local customer needs [Bruccoleri *et al.,* 2005].

Given the promising development in the past and the anticipation of further growth in franchising brands and their significant share of total economic output [AZFranchises, 2012], it becomes important to develop specially adapted changeable and agile production systems also for this sector.

The main objectives of this research and the development of the illustrated approach in this paper can be summarized as follows:

- Changeability through a modular and scalable expansion of the production systems capacity
- Replicability of the production system in the roll-out phase and expansion of the franchise system
- Identification of needs for production systems for franchise models using a systematic methodology
- Derivation of an appropriate guideline with a set of design parameters for production system designers
- Development of a holistic approach to design and implement a franchise system with decentralized production units, which includes not only technical but also organizational and strategic content
- Ensuring the practical applicability and validation using a case study.

Axiomatic Design provides a systematic approach to derive in a first step, the functional requirements (FR) and in a second step a set of design parameters (DP) for a changeable and modular production system for franchising models. By applying the Axiomatic Design methodology [Suh, 1990] and the MSDD approach [Cochran *et al.,* 2001] in this work, the requirements and specific design parameters could be achieved in a systematic and structured way.

The research in this paper is based on a real case study with a new North Italian franchise brand. The aim of the collaboration in this case study was to design and implement a modular and scalable production system for a network of distributed franchise production facilities. The application of the AD-based approach in the case study was very useful and effective for the systematic investigation of the requirements as well as for the elaboration of a concept for scalable and modular production systems for franchising networks.

2 LITERATURE REVIEW

In the current research, great attention is paid to changeability in production systems. There exist countless articles and research papers to this argument [Hernández, 2002; Reinhart *et al.,* 2003; Westkämper *et al.,* 2000; Spath, 2006; Nyhuis *et al.,* 2008; Yusuf *et al.,* 1999; Dove, 2006; Matt, 2010; Wiendahl and Heger, 2003; Wiendahl *et al.,* 2007; Park and Choi, 2008; Algeddawy and Elmaraghy, 2009]. Changeable systems are able to make anticipatory adjustments in addition to reactive interventions [Westkämper *et al.*, 2000]. The design principles of reconfigurable module-based production systems are: convertibility, flexibility, scalability, modularity, integrability and diagnosability [Koren *et al.*, 1999; Koren and Shpitalni, 2010]. Dove [2001; 2006] describes in his research concrete practical examples, how plant and machinery can be designed and constructed in a flexible and changeable manner.

2.1 CHANGEABLE, SCALABLE AND DISTRIBUTED PRODUCTION IN FRANCHISE MODELS

The above mentioned approaches usually have a universal and general character and hardly respond to special operational or organizational forms like franchising. In recent decades the topic of franchising was addressed almost exclusively from the business and legal side [Ahlert, 2001; Sydow, 1994; Bonani, 2004; Dant and Kaufmann, 2003; Dieses, 2004; Elango and Fried, 1997; Kubitscheck, 2000; Kunkel, 1994; Martinek, 2003; Martius, 2008; Metzlaff, 2003; Skaupy, 1995; Skaupy, 2003]. Manufacturing aspects were highlighted only very superficially. While there are a number of practical guidelines on the introduction of franchising and the creation of franchise manuals (e.g. Ahlert [2001]; Kieser [2010]) it is missing entirely a guideline for the planning, design and implementation of geographically distributed production systems within franchise networks.

Only a few authors have done research on production franchising and/or geographically distributed production. The following literature review summarizes the most important works on this argument:

Hayfron *et al.* [1998] developed firstly rough approaches for the design and implementation of production franchising networks. The authors show, however, only partially the requirements of the technical and organizational design of appropriate production systems.

Unlike licensing systems, a franchise system consists of the transfer of an entire business model and production concept from the franchisor to the franchisee [Bititci and Carrie, 1998]. Carrie *et al.* [2000] present in their research a few basic requirements for the successful implementation of production franchise models:

- The applied technologies and work processes must be established and tested (preferably by means of a pilot production facility)
- The model must be easily replicable
- The franchisor has the ability and expertise to transfer its know-how and knowledge to its franchisees.
- The staff of the franchisee must be able to be trained in an efficient, fast and economical manner.

Hildebrand *et al.* [2005] developed a so called PLUG+PRODUCE concept, which could be applicable also for franchise models. The research aims were to develop a modular factory concept, which should enable particularly for small and medium enterprises, to expand production without much effort and to move the production facility also to a new location. The research focuses on the design of a standardized "type factory" with the aim of duplicating it without great effort. However, the approach is based on a specific example of the industrial partner in the research project and can therefore be used only as a very limited guide for the design of production systems for franchising models.

Zäh and Wagner [2003] developed in their research project named "Market-oriented production of customized products" a concept of mini-factory structures. The objective of the project was similar to the project PLUG+PRODUCE, to develop a modular concept of a mini-factory for the purposes of mass customization [Reichwald and Piller, 2002]. The design of the mini-factory is based on a modular kit which differentiates in necessary basic modules and optional modules. The requirements for the mini-factories are similar to those from the task of this work, but it is strongly focused on the topic of mass customization. The concept therefore has significant weaknesses to apply for franchising models as there are no recommendations regarding the integration and refinement in a franchise network.

2.2 SYSTEMATIC APPROACH FOR THE DESIGN OF PRODUCTION SYSTEMS

Cochran developed an approach for the design of production systems, which is based on the principles of the Axiomatic Design approach [Cochran and Kim, 2000; Cochran *et al.,* 2001]. The focus of the methodology is on the derivation of so-called functional requirements (FR), and associated design parameters (DP). Axiomatic Design is a top-down methodology and therefore very systematic and structured. Starting from a main goal, a hierarchically structured catalogue of requirements with proposed solutions is developed. By breaking down (decomposition) of the top goals and design proposals can be identified specific design parameters at operational level. Cochran's methodology "Manufacturing System Design Decomposition" (MSDD) is the graph of the derivative FR-DP tree and very clear and easy to understand. In the background are analysed the interactions between the individual requirements and design parameters in a mathematical way. This results, ultimately, in an ideal sequence to implement the design parameters at the lowest level.

Also ElMaraghy and AlGeddawy [2009] describe Axiomatic Design as a very suitable and frequently used method to derive the target system as well as the requirements and evaluate the interactions of the identified requirements in a systematic way.

Bergmann applies the MSDD-methodology and thus the Axiomatic Design approach for the derivation of requirements for a sustainability-oriented holistic production system [Bergmann, 2010]. The work of Bergman proves once again, that the application of the Axiomatic Design methodology is suitable for a systematic and structured derivation of requirements and design parameters.

2.3 Research Gap and Need for Action

None of the shown approaches in literature, to achieve changeability and reconfigurability in manufacturing, provide information on the specific application in decentralized structures and franchising networks. All the discussed approaches show important and relevant findings for this work but they are only partially suitable and/or only generally formulated.

Thus, it is important to develop a comprehensive approach to the design of changeable and modular production systems for franchise models with geographically distributed production. Due to the property of the Axiomatic Design approach to consider the interactions between the various design elements, in the context of this work is used this method for deriving the requirements and design parameters.

3 SET OF PARAMETERS FOR THE DESIGN OF THE PRODUCTION SYSTEM

The AD-based approach for the determination and derivation of the design parameters can be basically divided into the following five usual steps in AD [Suh, 1990]:

1. Identification of customer attributes (CAs)
2. Transfer of customer needs into functional requirements (FRs) at the highest level
3. Assignment ("mapping") of solutions or design parameters (DP) to the respective functional requirements (FRs). In the assignment, the two axioms of Axiomatic Design to be considered:
    - The Independence Axiom in order to reduce the coupling of the system (avoid dependencies between the DPs and other FRs)
    - The Information Axiom for the selection of solution alternatives (choose always the "simplest" solution with the least information content)
4. Decomposition ("Zig-Zagging") into several hierarchical levels (top-down) to move from abstract requirements to concrete design parameters (FR-DP tree)
5. Development and revision of the design matrix.

3.1 Customer Needs and Functional Requirements on the Highest Level

The customer needs in this case study were identified through interviews with management and executives of the franchising company. Based on these interviews, the functional requirement at the highest hierarchical level (level 0), which is the main objective of the production system, was determined:

FR0: Building a network of changeable, scalable and economic franchise production facilities.

To meet this requirement, (FR0) was assigned on the physical design domain the following solution DP0:

DP0: Changeable and efficient production system for franchising models.

The proposed solution DP0 is formulated very abstractly and as expected it could not be a sufficient design parameter for the production system. Therefore it is necessary to split the top functional requirement FR0 into more detailed functional requirements at the next level.

3.2 Mapping and Decomposition Process

The mapping and decomposition process, starting from FR0, shows at the first hierarchical level five basic requirements, henceforth called the design fields (DF) of the production system:

FR1 Franchise-suitable and high qualitative products
FR2 Franchise-suitable network structure of distributed production facilities
FR3 Changeable, scalable, decentralized and cost-effective production of products
FR4 Affordable supply and logistics
FR5 Optimal and standardized processes.

The corresponding solutions to meet these functional requirements are:

DP1 Definition of products and services (assortment)
DP2 Franchise model and network structure
DP3 Changeable, scalable, replicable and profitable production units
DP4 Efficient supply structure
DP5 Franchise process organization.

The design matrix on level 1 shows the influence of the solutions (DPs) on the functional requirements (FRs):

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \\ FR_4 \\ FR_5 \end{Bmatrix} = \begin{bmatrix} X & 0 & 0 & 0 & 0 \\ X & X & 0 & 0 & 0 \\ X & X & X & 0 & 0 \\ X & X & 0 & X & 0 \\ X & X & X & X & X \end{bmatrix} \cdot \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \end{Bmatrix} \quad (1)$$

The design matrix shows a decoupled design. The functional requirements are not clearly distinguishable from each other, but can be uncoupled ordering them in a proper sequence. Therefore they show a useful or "good" system design. Figure 1 illustrates the graphical form of the FR-DP tree structure on hierarchy level 1.

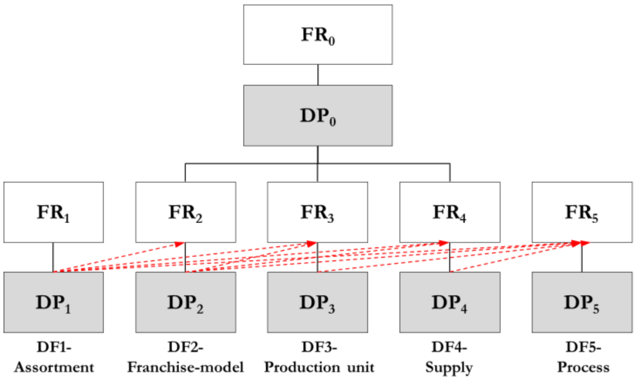

Figure 1. FR-DP tree - hierarchy level 1.

In their MSDD approach Cochran *et al.* [2001] visualize the dependencies between FRs and DPs in the form of arrow connections and align the structure of the FR-DP tree based on the principle that the picture is read from top to bottom (top-down) and from left to right (recommended sequence for iterating the DPs). Because those FR-DP pairs with most interactions with other elements are always located to the left, in the presence of a decoupled matrix, the correct path is necessarily the reading see "from left-to-right".

Starting from the decomposition of the first hierarchy level the decomposition process continues to the next levels. For a better understanding of the approach the decomposition is shown exemplary on one of the identified design fields (DF3-Production unit):

The functional requirement FR3 can be subdivided into three further functional requirements (see Table 1).

Table 1. Decomposition FR3 - level 2.

FR_{31}	Changeability of the production units	DP_{31}	Changeable & replicable production units
FR_{32}	Minimum production costs	DP_{32}	Elimination of non-value added activities
FR_{33}	Minimum overhead costs	DP_{33}	Reduction of assets, fixed capital and overheads

The design matrix shows a decoupled matrix.

$$\begin{Bmatrix} FR_{31} \\ FR_{32} \\ FR_{33} \end{Bmatrix} = \begin{bmatrix} X & 0 & 0 \\ 0 & X & 0 \\ X & X & X \end{bmatrix} \cdot \begin{Bmatrix} DP_{31} \\ DP_{32} \\ DP_{33} \end{Bmatrix} \qquad (2)$$

DP31 is concerned with the adaptability and replicability of the production units, but needs a further decomposition to be broken down into more concrete proposals for solutions (see Table 2).

Table 2. Decomposition FR31 - level 3.

FR_{311}	Changeability and flexibility of machines	DP_{311}	Design guidelines of changeable machines
FR_{312}	Gradual expansion of the production capacity	DP_{312}	Modular expansion levels (capacity, resources, layout)
FR_{313}	Minimizing the effort for the realization of a new production	DP_{313}	Replicability of the production unit without effort

The design matrix for FR31-DP31 is thus a triangular matrix and must be decoupled by the correct sequence.

$$\begin{Bmatrix} FR_{311} \\ FR_{312} \\ FR_{313} \end{Bmatrix} = \begin{bmatrix} X & 0 & 0 \\ X & X & 0 \\ X & X & X \end{bmatrix} \cdot \begin{Bmatrix} DP_{311} \\ DP_{312} \\ DP_{313} \end{Bmatrix} \qquad (3)$$

The design guidelines for changeable manufacturing systems and equipment (DP311) are based fundamentally on the changeability enablers: universality, mobility, scalability, modularity and compatibility [ElMaraghy and Wiendahl, 2009]. Table 3 shows the decomposition of FR311.

Table 3. Decomposition FR311 - level 4.

FR_{3111}	Easily shifting and movement of machines	DP_{3111}	Mobility by locally unrestricted machines (wheels, ...)
FR_{3112}	Universal use of the machines	DP_{3112}	Universal and flexible machines and work processes
FR_{3113}	Simply linking the machines	DP_{3113}	Compatibility with standard interfaces

The design matrix is again a triangular matrix (decoupled) and must be decoupled by the correct sequence.

$$\begin{Bmatrix} FR_{311} \\ FR_{312} \\ FR_{313} \end{Bmatrix} = \begin{bmatrix} X & 0 & 0 \\ X & X & 0 \\ X & X & X \end{bmatrix} \cdot \begin{Bmatrix} DP_{311} \\ DP_{312} \\ DP_{313} \end{Bmatrix} \qquad (4)$$

The same procedure was applied in the decomposition process for all other design fields and levels.

The result of the iterated decomposition process is the FR-DP tree with concrete design parameters at the lowest level (see Figure 2). In this work, the software Acclaro DFSS was used to create the design matrix and the FR-DP tree as well as to do a digitally assisted review and check of the independence axiom. The entire FR-DP tree consists of five hierarchy levels. FR-DP pairs marked with blue and the blue lines between DPs and FRs represents a path-dependent approach (decoupled). The FR-DP tree has to be read from left to right. Therefore this AD-based sequence in the FR-DP tree is also a recommendation for the sequencing of the various design parameters.

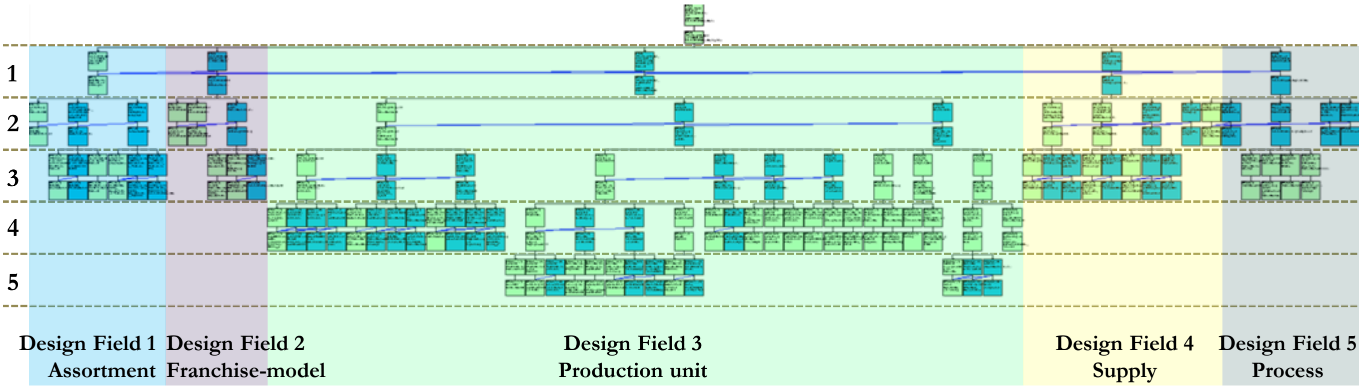

Figure 2. Full FR-DP tree with five hierarchical levels.

3.3 Design Fields and Design Elements

To guarantee a systematic modeling of the production system there were defined so called design fields (DF) (see also the first level of the AD-based decomposition). At this design level, independent from location-specific factors (such as labor cost) in the franchise system, the system designer could create a uniform and standardized template of the production system. The identified five design fields, with their set of design parameters, form the normative framework for the further expansion and development of the franchise system with geographically distributed production sites.

As a result of this study, the recommended sequence of this design fields could also be determined, in order to avoid iterative loops in the design process to the extent possible and to reduce the complexity to a minimum. Figure 3 shows the identified design fields (DF1 to DF5) and graphically describes the order in which the various fields should be treated. After determining the product or service assortment (DF1), the right franchise model (DF2) has to be defined. Once the franchise structure is clearly defined, the design of decentralized, changeable and profitable production units (DF3) needs to be elaborated. In a next step, the supply of the production facilities and outlets has to be modeled (DF4). Ultimately, it is necessary to standardize and summarize all results acquired in the design fields in form of processes and procedures (DF5).

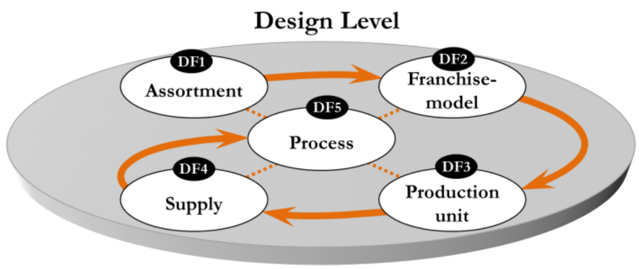

Figure 3. Five resulting design fields of the franchise production systems.

Within the design fields, the so called design elements (DE) are defined. A production system is designed and assembled element by element; therefore the design elements correspond to the derived design parameters in the decomposition process of section 3.2 (concrete design parameters and solutions at the lowest level of the FR-DP tree). A total of 50 design elements (see Figure 4) could be derived through the AD-based approach for the design of the franchise production system, which in their totality constitute a very useful tool for the system designer.

The design elements DE4-DF3 to DE23-DF3 (see dashed area in Figure 4) can also be combined into a macro-block "lean and green production". They include a number of known methods of lean manufacturing and the Toyota Production System. As part of the trend of resource scarcity and higher energy prices, the term "energy efficiency" will become more and more important. Therefore, together with the term "lean" is often used the synonym of "lean and green".

4 Approach for Implementation – A Three Level Model

The previously presented design fields with their design elements form the normative framework and the basis for the expansion and multiplication (roll-out) of the franchise production system. However, for the testing of the production system as well as for a systematic and prudent roll-out important elements are missing on a strategic-tactical level and the operational level. To give system designers a tool for the design and implementation of franchise production systems the following three-level model is proposed (see Figure 5).

4.1 Level 1 – Design Level (Normative Framework)

At the normative level, the system designer defines the design of the franchise production system. At this level, the design fields with their design elements are elaborated and defined. Thus the modeling framework with its design templates is created. The horizon of the design level is long term and is thus over a period of five years. Periodically, the design fields and elements, however, should be checked for any necessary adjustments (trigger point for the re-design of the production system - see also [Matt and Rauch, 2011]).

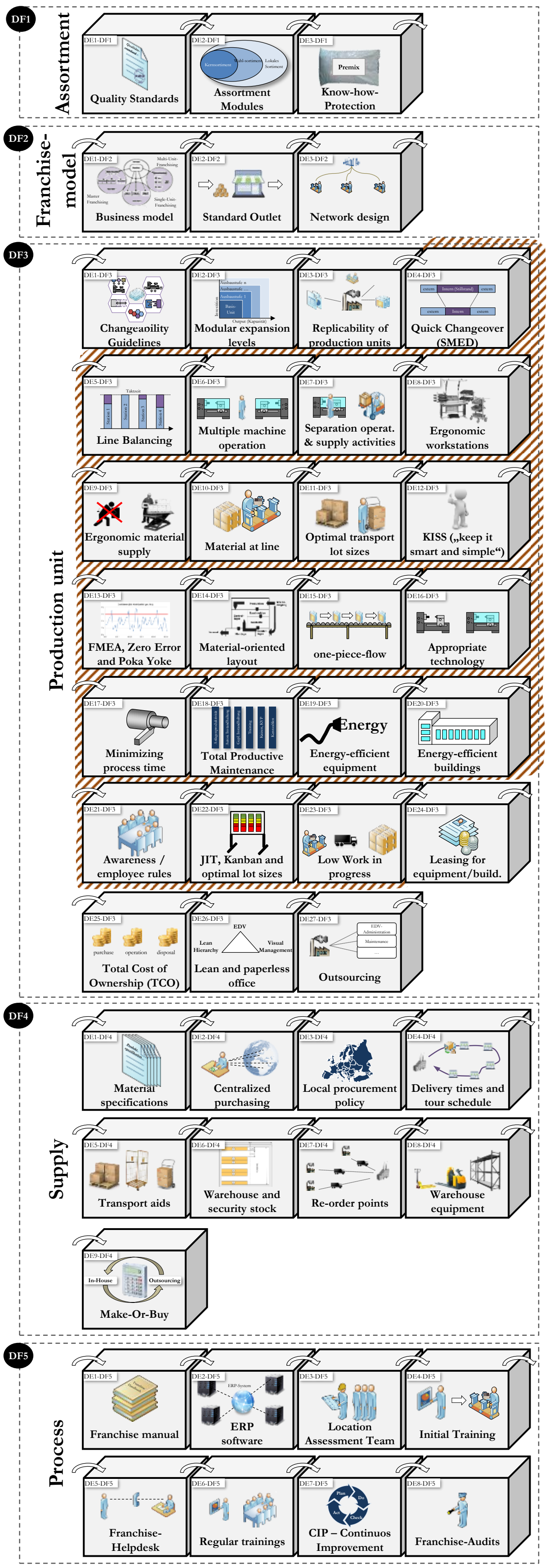

Figure 4. 50 design elements (DE).

4.2 Level 2 – Planning Level (Strategic-Tactical Framework)

Once, the design parameters or elements for modeling the production system are developed on the design level, they have to be tested through the realization of a pilot production unit. The first step in the strategic and tactical planning level is planning and implementation of a pilot plant. The pilot production unit, which is operated by the franchisor itself, has to test and develop new products and production technologies. Once, the pilot production is consolidated by iterative feedback to the design and operational level and the profitability of the business model has been proven, finally the multiplication of the production units and thus the roll-out of the franchise model can be started. Before the start of the roll-out a multi-year scenario plan or business plan is being developed. This business plan includes not only the potential regions and countries, but also the number of planned outlets and production units as well as the time line for its implementation. The time horizon for this level includes the strategic planning in a time frame of three to five years and an annual, detailed tactical planning and budgeting.

4.3 Level 3 – Operational Level (Operational Framework)

The operational level comprises the implementation of the production units and the operational tasks of the franchisor with all his responsibilities. Of particular importance is that before the start of the roll-out, all processes and operational issues (e.g. ordering procedure in the outlets and production units, integrated data management, process for product development, etc.) are tested and examined in the pilot production. As shown in Figure 5, iterative feedback loops ensure that only a functional and viable production and franchise system is transferred to the franchisee. If not, there is a risk of failure of the franchisee and of the entire business model. The time horizon for the operational level is dominated through "daily business" and therefore shorter than one year.

4.4 Feedback Loop (Re-Design and Re-Planning)

As described in Figure 5, between the different levels there is an iterative feedback loop, similar to a control loop, to transfer the experiences from the pilot production unit to the other levels while "adjusting" and consolidating the production system. Between the different levels, we can distinguish two types of feedback loops or trigger-points:

– Feedback loop on the design level ("re-design")
– Feedback loop on the planning level ("re-planning").

The experience gained from the pilot production unit, as well as its reconfigurations, is transferred through the iterative feedback loops to new production units (roll-out). By the above described regular and systematic feedback loops and the continuous adaptation of the design level the ability to change and adapt, the entire production system can be guaranteed.

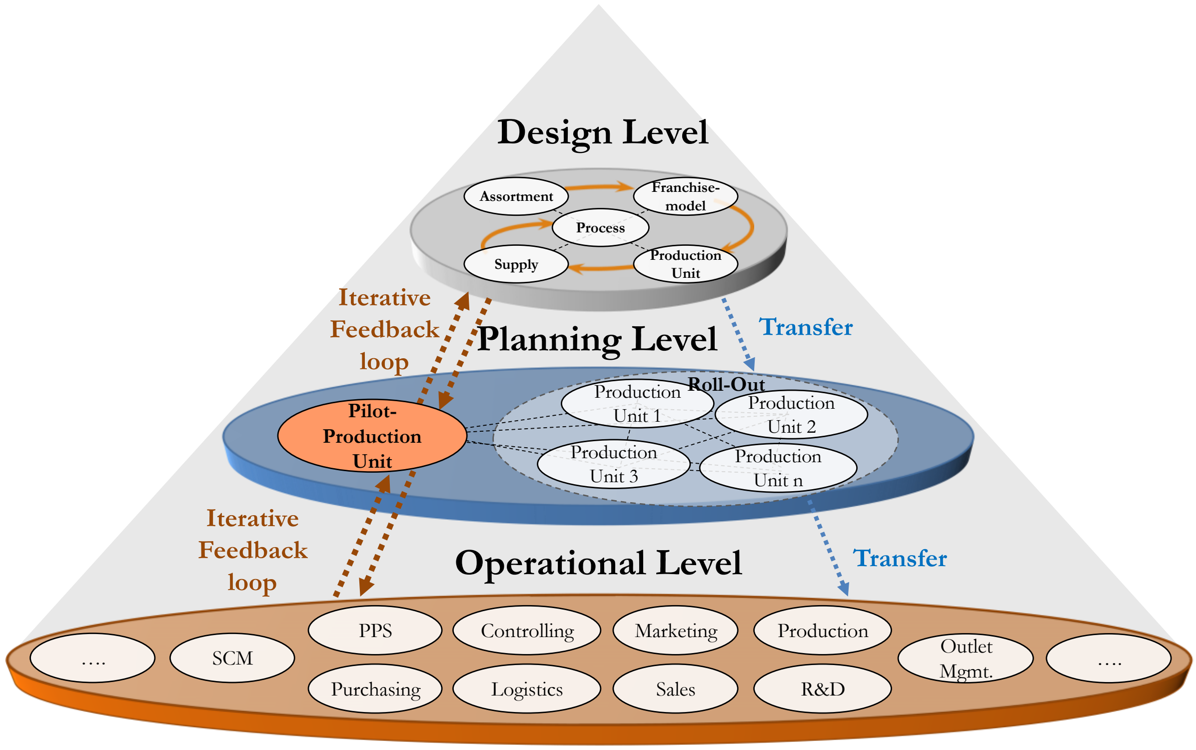

Figure 5. Three-level model for the design, planning and operation of a franchise production system.

5 APPLICATION IN A CASE STUDY

The shown approach was developed and applied in a real case study and subjected to validation. The company in the case study is a new Italian franchise brand, which began its activities several years ago with the opening of its first own outlets. The business idea is based on the concept of coffee shops with an integrated shop. The specialty of the company in the case study is the combination of coffee shop and self-made products in the shop.

For the production of its own products, the company has established in advance an own pilot production unit, which first developed and produced in a traditional manner the products for the pilot market. With an increasing pilot market also the pilot production developed the industrial production methods. After the initial experience with the pilot production and outlets in the pilot market, the company pursued the vision of an international chain of franchise outlets and started at the end of 2010 a project for the development of a concept for global expansion and the related supply of the outlets. Due to the required freshness of the products and the limited shelf life and because of possible local needs of customers in the target countries, the company decided to produce with geographically distributed franchise production units. The case study showed very clearly, that the implementation of such a franchise system without a suitable methodology would take very long and can be disturbed by frequent iterative loops in the planning and design phase. The approach described in the paper was applied in the case study and was very helpful for the company. Through the approach, not only the design parameters for the production system could be defined, but also a simple and systematic approach for its implementation was developed.

6 CONCLUSION

By the "top-down" AD-based approach and the decomposition process a holistic overview of the requirements and design options was created. In addition, through the application of the methodology and the consideration of the Independence Axiom the correct sequence for the determined design parameters could be identified. By the presented three-level model system designers can find for the first time a complete and technically, economically as well as organizational aligned model for the design and implementation of changeable production systems in franchising. With this model, a scientific contribution is made to close the demonstrated research gap shown in section 2.3.

The application in the case study showed that the one-time expense and effort in the AD decomposition, to develop the design fields and to create the normative framework on the design level is not negligible, but then offers great benefits through a quick and high-quality design, planning and implementation of the production system in franchise models. In summary it can be said that the objective of this work was accomplished and the system designer with the presented approach receives a useful tool for the successful design and implementation of changeable and modular production systems for franchising models.

Further research will be done to investigate and define the trigger points for regular adaptation of the production system in a systematic way.

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