

## INTERFACING PRODUCT DEVELOPMENT AND FACTORY PLANNING – TOWARDS A UNIFIED LIFE CYCLE MANAGEMENT

Politze, D. P.; Bathelt, J.; Reinhard, M.; Jufer, N. & Kunz, A.

**Abstract:** *In this paper, a product's life cycle and an analogue life cycle of a factory are analyzed. Inputs and outputs of the corresponding design phases are described and their dependencies are examined from different point of views. After a detailed discussion of the results, interfaces and integration possibilities are enlightened.*

*Key words: Product Development, Factory Planning, Life-Cycle-Management*

### 1. INTRODUCTION

The idea of a Factory Life Cycle was first mentioned from Roger W. Schmenner [1] who states that, factories may also have an assigned life cycle. In recent publications this Factory Life Cycle concept is derived from the work of Westkämper [2] who further recognizes the "Factory as Product" paradigm [3]. According to that, a factory may be seen as a very complex type of product with a long lifetime. In turn, this point of view also leads to the application of a product's life cycle concept on a factory.

This new kind of product itself is responsible for the manufacturing of other products with a shorter lifetime under the constraint of an ongoing operational, tactical and strategically change and the required adaption to it [4].

Current research addresses these issues by developing new design methods for the Factory of the Future and by integrating new technologies and tools, which may be used to manage factories, products, processes and technologies over their life cycle from engineering up to

decommissioning. Within [4] such an approach is referred as Unified and Sustainable Life Cycles Management and envisions an orchestration or harmonization of the specific life phases of products, production systems and corresponding design methodologies.

The life cycle concept has gained importance in the recent years and will grow in the future as well. The expectation of a life cycle perspective and its integration with the product and factory life cycle should ensure a shorter time to market and significant cost savings.

Especially the reduction of the time to market will be a key advantage in future competition on a globalized economy with shorter lifetimes of products. This work intends to give an idea about the potential of harmonizing and synchronizing the product and factory life cycle and it will provide an answer to where the biggest potential for improvement lies.

This is done by an analysis of two reference processes of product development and factory planning. The processes are analyzed on four layers; product, logistics, finance and project. The idea is to split the two processes on different layers and to analyze each step with an input-output analysis. The result of this analysis will contribute to a better understanding of the interfaces between product development and factory planning. Generally, the sequential development of a product and the following planning of the corresponding factory require too much time and the optimal solution for product and factory is not reachable due to the missing exchange of relevant planning

information. Therefore, an integrated and concurrent planning approach is envisioned which bases on an orchestration or harmonization of the design phases within the life cycle models of products and factories.

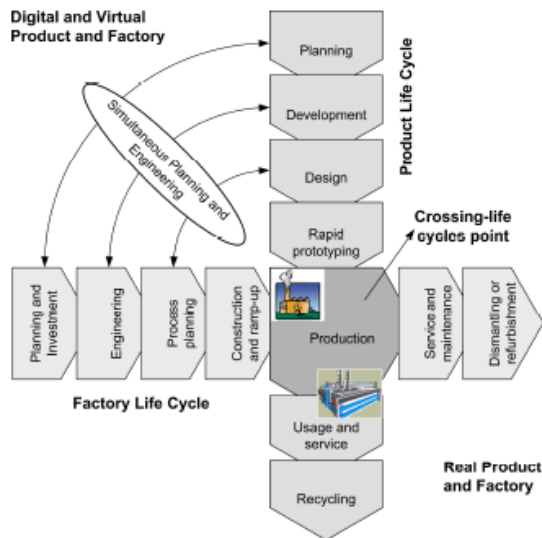


Fig. 1. The harmonization of product and factory life cycle [4]

In Fig. 1 the two life cycles and their crossing point - the production – are presented. Depicted in the top left corner, the interfaces between the two life cycles are the main focus of this paper.

As it can be inferred from the picture, the analysis of the early stages (i.e. product development and factory planning) will support the finding of interfaces between the two life cycles and hence lay out a foundation for a better integration.

Thus, in the next section the product development approach and the planning approach that have been used for the analysis are described. Then section 3 sketches the used research approach. The result of the analysis is presented in section 4 before section 5 concludes.

## 2. BASIC CONSIDERATIONS

Every innovation process and factory planning process emerges from the business strategy and vision of an enterprise. The objectives of an innovation

process are derived from these fundamental guidelines. This strategy gives a quantitative character to the vision and is therefore also the benchmark for the successful accomplishment of the vision.

Besides, the analysis of the market is also a key element for product development and factory planning. Aspects like product-market, competitors, patents, technologies and regulations have to be analyzed and evaluated. The outcomes of this analysis are boundaries for the succeeding product development process and/or factory planning. Exemplary, two such processes will be regarded within the research of this work. Both start with the above explained market and vision phase and then differ as described in the following subsections.

### 2.1 Product Development

The product development process given in this section is mainly based on the work of Mital [5] and very similar to the accepted approach of Pahl and Beitz [6] and the VDI guideline 2221 [7].

The approach considers the market and thus the customer needs as key drivers of the development process, while not valuing that much the corporate policy or vision and the business strategy.

After a market and vision, the first phase in the product development process is the market achievement process. Its intention is to define the requirements and overall description of a future product. The output is the contract specification sheet.

The objective of the succeeding conceptual phase is to find solutions that meet the predefined requirements from the contract specification sheet. Usually in this phase a bunch of possible solutions is created for every intended function of the future product. Those solutions are then evaluated and the best one is chosen. Hence, the outcome of this phase fixes the working principle of the solution and already sets geometrical and structural constraints which also have an influence on time and cost parameters.

Within the next phase, the design process, the solutions that have been roughly defined at the conceptual phase shall be refined and detailed. The design process can be divided in three sub processes. The final outcome is a detailed specification of the product. The design process is iterative and thus continuously leads to new recognitions and difficulties that have to be solved. Finally, the Bill of Materials (BoM), the cost structure and the complete draft should be available.

The last phase in the exemplary product development process is the realization process, which mainly deals with the implementation of the previous results. Subsequently, this is directly followed by the market introduction that copes with lot sizes, delivery to costumers and the further development of the product. The outcome of this phase, should be a working supply chain and production, which allows the company to earn money for their investments.

Due to their strong relation, the realization process and the market introduction process can be easily merged.

## 2.2 Factory Planning

In this section the factory planning approach is described that has been used exemplarily for the analysis. The chosen approach bases on the accepted work of Pawellek [8], which merges the findings of Schmigalla [9] and Grundig [10].

The holistic factory planning method lays its focus on network issues and declares the logistics as a central part of the planning procedure which has to be considered on every planning level.

As indicated in the beginning of section 2, this approach has also a market and vision phase as a first step.

This is followed by the definition of a strategy that intends to describe the aims and objectives for technology, organization and related assets.

The next phase is the structure planning which intends to connect all elements of the factory system to a general structure of

the factory. The resulting order of the factory units has to be done with regard to production, logistics and organizational factors and requires an enormous effort in collecting relevant data. The outcome of this planning phase is a rough definition of functional units whose connections and interfaces are elaborated and specified. At this point the material flow is mainly fixed and thus determines the overall layout of the future factory.

The system planning is the next phase of the exemplary factory planning approach and intends to specify the different functional units in more detail. Therefore, this step comprises the planning of production and assembly lines, warehouses and transportation, organizational aspects and the infrastructure. The final result of the system planning phase is a clearly defined and detailed plan about the whole factory.

The succeeding implementation and ramp-up phase of the factory planning approach is about building the factory itself. Additionally, the personnel development for the factory has to be ensured and trained before the ramp-up, which is the definitive takeover of the factory by the operational unit.

## 3. RESEARCH METHOD

The analysis that has been carried out for this work bases on a flow based model and assumes specific inputs and outputs for all regarded phases. The inputs are necessary to execute a phase of the product development or factory planning and the outputs.

In a first step these inputs and outputs have been collected according to different perspectives in order to reduce complexity. For each planning phase described in the previous section a table is created that lists all inputs and outputs of a specific phase. As an example, Table 1 shows the inputs and outputs for the system planning phase that are related to logistics.

Input	Output
- Material flow and warehousing defined	- Transportation between the functional units defined
- Production organization defined	- Buffers and production control and planning defined
- Special solutions with suppliers and customers defined	- Departments and structure detailed defined

Table 1. Inputs and outputs of the system planning phase in product development

Afterwards, the analysis is conducted which aims at finding interfaces between the phases of the product development and the phases of the factory planning. The idea is to connect the outputs of each phase with the required inputs of other phases in order to identify potential interfaces. At the end, a complex interface structure should be evolved to serve as a basis for the envisioned harmonization or orchestration efforts in current research.

As indicated above, the analysis of the processes and the interfaces is split according to four different viewpoints. Besides the reduction of complexity, this allows a simple and fast analysis of the interfaces. These viewpoints were chosen based on reviewed literature and distinct elaboration. The viewpoints are:

**Product:** describes all relevant inputs and outputs concerning technical matters like product specifications, quality issues, production technology etc. Additionally, the production process is a matter of this layer but with a strong relationship to the logistics layer or directly to the material flow.

**Finance:** specifies all financial issues like life cycle costs, TCO, investments, financial KPI's, financial flows, etc.

**Logistics:** is about supply chain management issues, internal and external logistics, material flow, transportation etc.

**Project:** describes project issues relating to product development or factory planning e.g. project scheduling, responsibilities, human resources issues etc.

#### 4. ANALYSIS OF THE INTERFACES

The product viewpoint, as depicted in Fig. 2, shows that both product development and factory planning aim at introducing a product to the market.

The other viewpoints may be regarded as boundaries and thus should be regarded with lower priority in a harmonization and orchestration attempt. Since a planning of product-related inputs and outputs has huge implications on time and costs, the planning related to other viewpoints has to take a supervision function into account (i.e. this applies for the logistics and financial viewpoints).

The inputs and outputs related to logistics are directly linked with the inputs and outputs related to the product. Thus, decisions about production processes are directly dependent on logistic decisions.

One reason for that lies in the dependency of the material flow on the definition of assemblies and modules. Furthermore, in the context of factory planning the external logistics, which is defined by the customers and suppliers, sets limitations and objectives for the production.

The capacity as a main trigger for logistics has a big impact on the whole supply chain and therefore serves as a basis for the design of the supply network.

The analysis supposes that product development is not really bothering with the impacts of logistics in its phases which in turn leads to problems regarding integration in the already existing supply network and also the integration of new suppliers, what is a key issue for the factory planning at its beginning. This information is needed for a proper implementation of the logistics network and the factory. An insufficient integration of the supply network into the new factory

leads to high disturbances and additional costs.

Therefore, there are also dependencies between the product and the financial viewpoint as well as between the logistics and the financial viewpoint.

This is because the financial aspects are partly defined by the planning of warehouses, buffers, etc. which has an impact on investments and the capital.

Generally, the financial related viewpoint can be seen as a cockpit for the management. Based on the analysis of costs for production and investments the final decisions and approvals of the management are done.

The overall analysis of the financial viewpoint is actually quite simple. Through the initial vision and market phase there exist clear objectives and also an expected performance. Thus, these objectives and expectations have to be ensured in all

phases of product development and factory planning.

Since the project related viewpoint aims at exchanging data for reporting and monitoring, this viewpoint is the least important one. The corresponding inputs and outputs are more about supporting and providing guidelines to all the phases and are not really dependent on any other viewpoint.

Generally it may be stated, that the main result of the analysis is that the product viewpoint has to be seen as the most important perspective for the harmonization and orchestration effort of product development and factory planning. The analysis has shown that generally the conceptual planning in product development has no inputs for the strategy planning in factory planning. On the other hand, the following design process and the structure planning are more important.

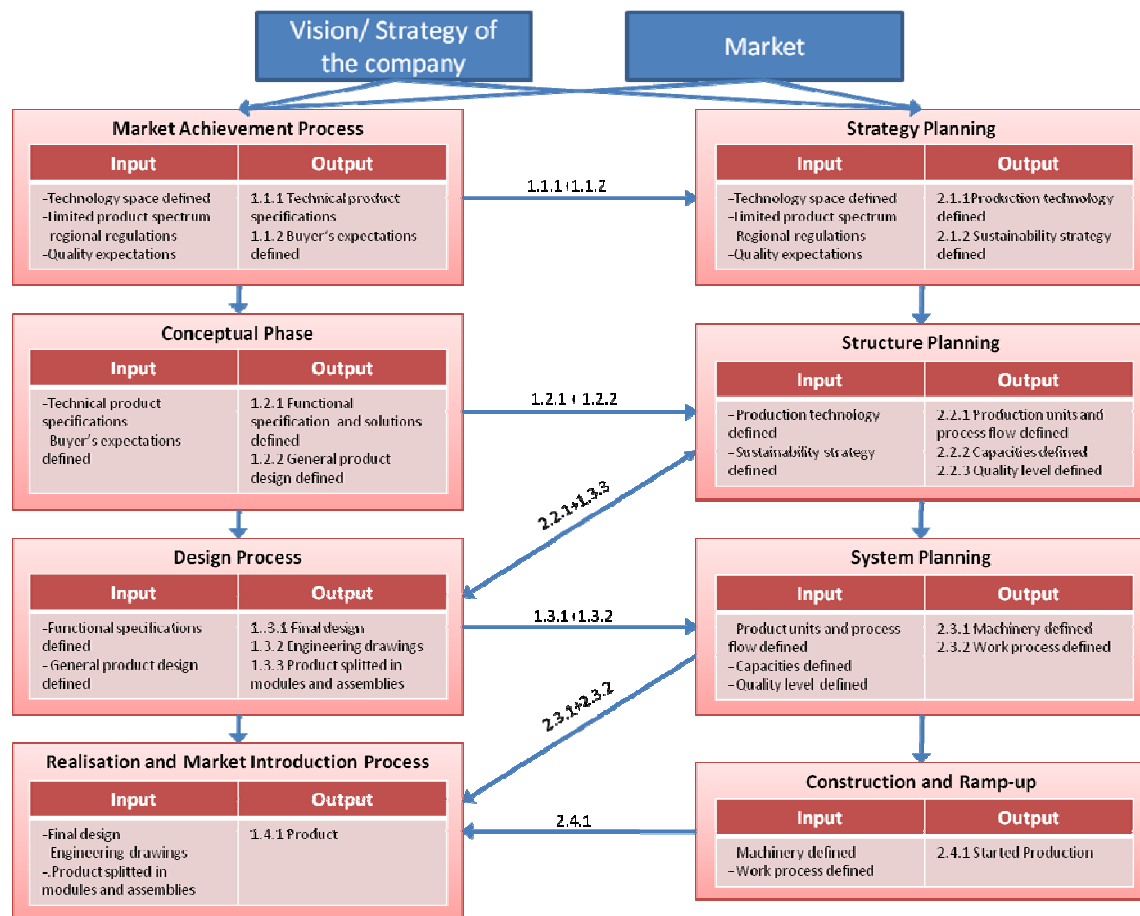


Fig. 2. Input and output dependencies according to a product related viewpoint

The design process phase of the product development, with its module and assembly definition, is the blocking element for the factory planning and forces the start of the structure planning phase to delay until the middle of the design process.

In analogy to that, the system planning step of factory planning is a blocking element for the market introduction phase of the product development.

## 5. CONCLUSION

This paper outlines how product development and factory planning can be harmonized. Furthermore, it points out the leverage points that have the highest potential for improvement.

It has been shown that the optimization and integration of the market achievement process and the strategy planning of the factory is a valuable solution. Moreover, the bottleneck in factory planning while defining modules and assemblies in product design is demonstrated.

In addition to the above, it has to be noted that the results are limited by the deepness of the conducted analysis and by the chosen reference processes for product development and factory planning.

Finally this work is limited by that fact that this work assumes a green field, where neither the product nor the factory exists. In reality, product development and factory planning is often based on already existing products and factories. Further research on this topic has to take this fact into account.

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## REFERENCES

- [<sup>1</sup>] Schmenner, R. W. Every Factory has a Life Cycle. *Harvard Business Review*, 1983, **61(2)**, 121-129.
- [<sup>2</sup>] Westkämper, E., Constantinescu, C., and Hummel, V. New Paradigm in Manufacturing Engineering: Factory Life Cycle. *Production Engineering*, 2006, **1**, 143-146.
- [<sup>3</sup>] Aldinger, L., Constantinescu, C., Hummel, V., Kreuzhage, R. and Westkämper, E. Neue Ansätze im Advanced Manufacturing Engineering. In *Werkstattstechnik Online*, 2006, **3**, 110-114.
- [<sup>4</sup>] Pedrazzoli, P., Rovere, D., Constantinescu, C., Bathelt, J., Pappas, M., Dépincé, P., Chryssolouris, G., Boër, C. R. and Westkämper, E. High Value Adding VR Tools for Networked Customer-driven Factory. *Proc. of the 4th Intl. Conf. on Digital Enterprise Technology (DET2007)*, Bath, United Kingdom, 2007, 19-21.
- [<sup>5</sup>] Mital, A., Desai, A., Subramanian, A., and Mital, A. *Product Development; A Structured Approach to Consumer Product Development, Design and Manufacture*. Butterworth-Heinemann, Oxford, 2008.
- [<sup>6</sup>] Pahl, G., Beitz W., Feldhusen, J. and Grote, K. *Konstruktionslehre, Grundlagen erfolgreicher Produktentwicklung Methoden und Anwendung*. Springerverlag, Berlin, 2006.
- [<sup>7</sup>] VDI-Richtlinie 2221. *Methodik zum Entwickeln und Konstruieren technischer Systeme und Produkte*. Beuth Verlag GmbH, Berlin, 1993.
- [<sup>8</sup>] Pawellek, G. *Ganzheitliche Fabrikplanung: Grundlagen, Vorgehensweise, EDV-Unterstützung*. Springer Verlag, Berlin Heidelberg, 2008.
- [<sup>9</sup>] Grundig, C. *Fabrikplanung: Planungssystematik-Methoden-Anwendungen*. Carl Hanser Verlag, München, 2009.
- [<sup>10</sup>] Schmigalla, H. *Fabrikplanung: Begriffe und Zusammenhänge*. Carl Hanser, München, 1995