DOI: 10.2195/lj_NotRev_behmueller_en_201409_01
URN: urn:nbn:de:0009-14-39927

Development of a process model for the automatic miniload warehouse expansion

Entwicklung eines Vorgehensmodells zur Erweiterung von Automatischen Kleinteilelagern

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This paper provides an insight to the development of a process model for the essential expansion of the automatic miniload warehouse. The model is based on the literature research and covers four phases of a warehouse expansion: the preparatory phase, the current state analysis, the design phase and the decision making phase. In addition to the literature research, the presented model is based on a reliable data set and can be applicable with a reasonable effort to ensure the informed decision on the warehouse layout. The model is addressed to users who are usually employees of logistics department, and is oriented on the improvement of the daily business organization combined with the warehouse expansion planning.

[Warehouse planning, expansion, process model, automatic miniload warehouse]

Diese Veröffentlichung gibt einen Einblick in die Entwicklung eines Prozessmodells für die Erweiterung eines Automatischen Kleinteilelagers. Das Model basiert auf einer Literaturrecherche und behandelt die vier Phasen einer Lagererweiterung: Vorbereitungsphase, Ist-Analyse, Designphase und Entscheidungsphase. Ergänzend zur Literaturrecherche basiert das Modell auf einer belastbaren Datenbasis und kann mit einem der Aufgabenstellung angemessenen Zeitaufwand angewandt werden, um eine fundierte Entscheidung über das Lagerlayout zuzulassen. Das Modell richtet sich an Nutzer die im Bereich Logistik arbeiten und hilft dabei, neben dem Tagesgeschäft die zusätzliche Aufgabe einer Lagererweiterung zu bewältigen.

[Lagerhausplanung, Erweiterung, Prozessmodell, Automatisches Kleinteilelager]

1 Introduction

In industrialized countries electronics is an integral part of a daily life. Whether it is brushing teeth with the electric toothbrush, reading E-mails at work or turning on/off the light, electronic means are used to make the daily life more convenient. According to the Central Association of the Electrical and Electronics Industry (ZVEI, 2012), the increasing demand for electronic hardware is reflected by the worldwide growth rate for electronic industries by an average of 6 percent over the last three years (2011-2013). The result of the growing demands are increasing sales. This directly influences the logistic structures, which include the provision of customers (end-consumer, external- or internal production, etc.) with supplies from a centralized warehouse. The logistic structures are also influenced by the goods structure effect, when nowadays instead of supplying the customer with the bulk goods, the customer is provided with individual deliveries of high price items. Therefore, the total sum of delivered parcels is increasing, whereas the amount of articles per package is decreasing. This is why the electronic industry has to expand (more parcels are send) and optimize (zero picking errors) its existing logistic structures. This challenge is rather easy to be handled for big businesses because they have the necessary financial and personnel resources. However, for medium-sized companies it seems to be a challenge, because they might not see the importance of the logistic structures or simply do not have the resources for the necessary expansion and optimization processes. Paying no regard to the renewal of the logistic structure might give the competitors the advantage of a better cost structure and in the long run will lead to the company fall.

The individual storage system is highly dependent on sort of goods stored in the warehouse (Heinrich, 2011). In the field of electronic industry, mainly general cargo of small sizes is dealt with. Due to relatively small sizes of electronic components, in many storage systems of the

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electronic industry automatic miniload warehouses (AMW) are used. They enable a fully automated storage and retrieval of unit loads. Taking into consideration the growth rates of the electronic sector and, thus, the increasing necessity of the storage space optimization, the question arises: "How shall the existing warehouse be expanded and optimized?"

2 AIMS OF A WAREHOUSE EXPANSION

The main aim of this study is to develop a process model for the expansion of a warehouse including the storage system technology and the accompanied processes. This model has to enable medium-sized companies to carry out a warehouse expansion using their internal resources. To achieve this goal two requirements have to be taken into consideration: (1) the user of the model has to be known and (2) the needs of a modern warehouse system have to be met.

Firstly, the employees in charge of carrying out special projects, such as a warehouse expansion, are often not sufficiently relieved from their day-to-day business. Therefore, it is important to create a simple and user-friendly model that can be understood and applied within a reasonable amount of time. At this point, the principle of "using multiple simple models instead of one complicated model" must be taken as a base, avoiding the recent tendency to develop very complex and sophisticated models (Appelo, 2012). In contrast to more generalized existing models (Gudehus, 2012; Heinrich, 2011; Mohsen, 2002), the process model presented in this study is developed in the way, that it can be precisely adjusted to the needs of a warehouse expansion, and it gets along with just a few basic methods (project management, balanced score card, etc.) and essential data analysis. By adjusting the process model to the special case of the warehouse expansion, the model loses an omnipotent character, but it is much more accurate in its explanatory power with respect to the warehouse expansion.

Secondly, the process model must meet the needs of a modern warehouse system. Starting point for a contemporary warehouse design is the lean management. The aim of the method is to ensure the coordination of all the activities involved in the value chain and to avoid wasteful activities. In the lean concept, the existing processes have to be viewed from two perspectives – customer and company, whose needs become the central core of the model. From customers' point of view, the ordered goods or services must be delivered according to the quality–cost–delivery (QCD) approach (Domingo, 2013; Riedler, 1997). Quality is the characteristic required by the customer that represents the primary value of the goods and usefulness of them for the customer. Cost perspective refers to the amount of money which the customer is willing to pay for the goods as well as the cost of producing and delivering the product to the customer. Delivery involves bringing the finished goods to the customer at the right time, in the right amount, at the right place. An essential point here is that QCD is an integral approach for the customer, where each of the three parameters are equally important and should be satisfied at once: the customer desires to get a high quality goods at the appropriate time, at the reasonable cost and right quantity.

At the same time the company's aim of the warehouse expansion is to develop an economical, flexible and attractive warehouse system. According to Grundig (2013), this results in the definition of the following objectives:

1) To ensure high efficiency. This implies that the goods in the warehouse should be handled with minimal lead times and in reasonable amounts, delivered to the customer at the appointed times and according to the required quality standards. The whole process should be carried out largely avoiding non-productive activities. Here, a logistics-oriented production-, material- and distribution flows, as well as maximum utilization of equipment, room space and staff must be ensured.

2) To ensure high flexibility and permanent adaptation to the changes of external (e.g. sales fluctuations) and internal parameters (e.g. start-up of the product), flexibility and adaptability of facilities, processes, spatial patterns, building systems and organizational services have to be considered.

3) Ensuring of high attractiveness is determined by motivational, human working conditions, remuneration and social conditions, as well as the implementation of modern, aesthetic industrial architecture of the factory building (corporate identity).

Fulfilling the requirements discussed above is an indispensable condition which is considered to be fundamental at this stage and could serve a good base for the successful development of the process model for the warehouse expansion.

3 SISYPHUS-MODEL

The main idea of the process model presented in this study refers to the story of Sisyphus – a legendary figure of Greek mythology who was condemned by the gods to push a huge boulder up to the top of a hill again and again, since the stone rolled back down every time Sisyphus reached the summit (Köhlmeier, 2007). The repetition of the same everlasting task without successfully finishing it can be concerned as a "Sisyphus problem". Making the parallel to the topic of the storage space opti-

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mization, the developer who is in charge of a new warehouse expansion planning, has to find a proper solution for that complex task in order not to become a Sisyphus. For instance, one of the solutions of the Sisyphus problem could be splitting the total distance to the summit into shorter parts, instead of covering the entire way at once. The same can be done regarding the warehouse planning: the highly complex task of a warehouse expansion can be divided into individual project phases consisting of a number of manageable subtasks. This idea is implemented into the process model presented in this study, named SISYphus Problem Solving model (later in the text referred to as the SISYPhuS model) and shown in the figure below.

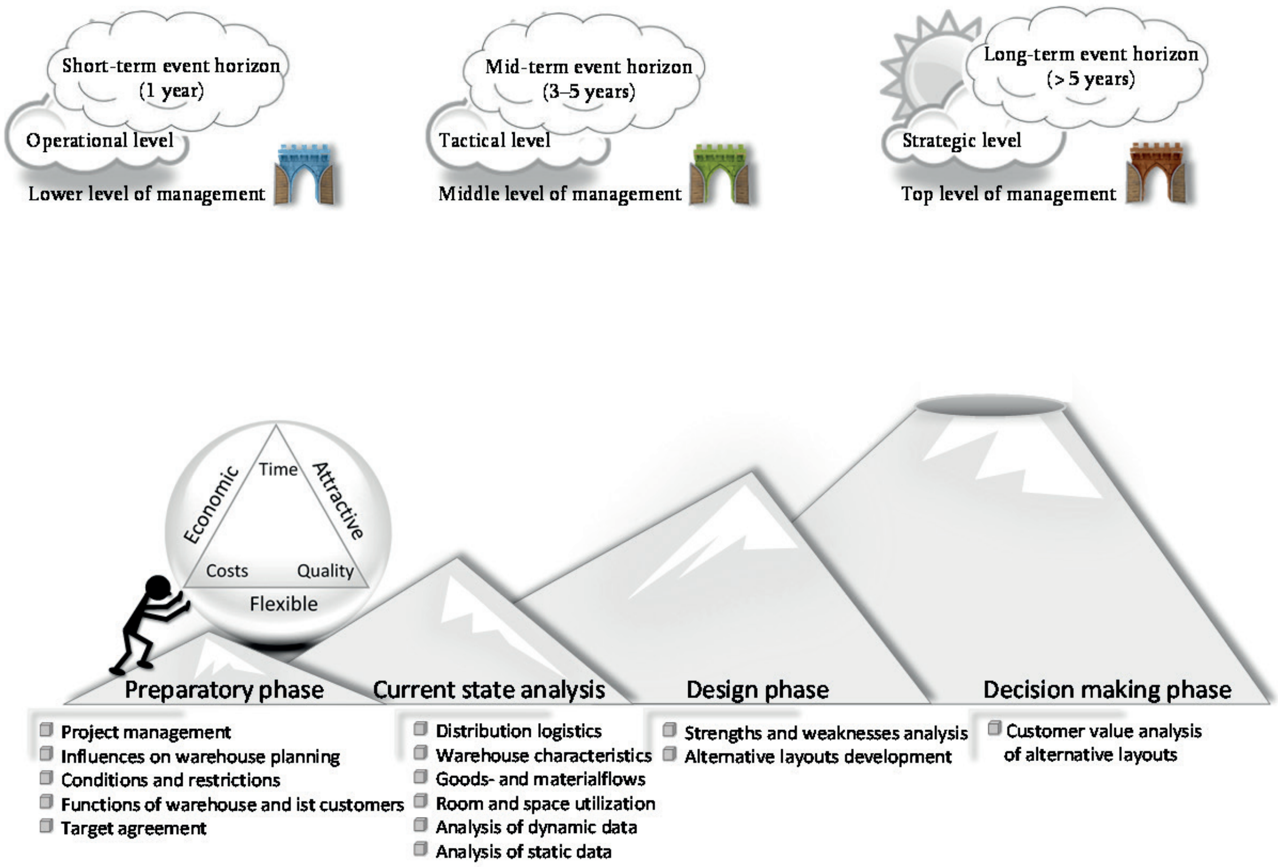

Figure 1. SISYPhuS Model

The basis of the model shown in the figure, is partially referred to the target and rough planning phases of the model suggested by Heinrich (2011). In this study, we propose to reorganize the whole process of the warehouse expansion planning into four main stages: preparatory phase, current state analysis, design phase and decision making phase. In its turn, each phase consists of a certain number of tasks which might differ from project to project, depending on the purposes and requirement of the end-product. Only after successful accomplishment of all tasks within one particular phase, the execution of the next phase can be started. The main concepts for each phase are based on a literature research and are presented in the subchapters below.

3.1 Iterative approach as a tool for a successful model

A well-designed model must guarantee the user to get reasonable and satisfactory results after the model implementation. To optimize the logistics model and to avoid any kind of mistakes during the intermediate phases, an iterative approach between these phases as well as within a single phase of the model can be installed (Gudehus, 2012). This implies that arriving at a decision or getting a desired result can be done by repeating rounds of analysis or a cycle of operations. And only after a critical task (phase) or subtask (work package) is successfully completed, the planner can proceed to the next phase by passing through so called "gates", which are standing for the approval of interim results by decision makers. Otherwise, the work must be improved until the required output and

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the key performance indicator are successfully reached. For example, after completing the work package "Target agreement" of the preparatory phase (see figure), an agreement with the management level must take place, only then it is possible to proceed to the next phase “Current state analysis”. This procedure ensures that the developed project goals are consistent with the corporate and departmental goals. However, the installation of gates is still not sufficient to provide an effective controlling mechanism which fully prevents the generation of unfit results. For this purpose additionally a temporal dimension of management decisions must be introduced (Heinrich, 2011), and if this is the case, then the decisions to be made need the approval on different management levels (low, medium or high). Depending on the field of responsibility they are covering, operational, tactical or strategic management levels with different time event horizons (1 year, 3–5 years, > 5 years) are also introduced into the model (Tempelmeier & Günther, 2005). For example, if due to the expansion of a warehouse it was decided that the incoming goods department should be reorganized, then it would be the operational level of management in accordance with which this task has to be done (because only the operational level of management is familiar with the daily processes carried out in the warehouse). The full iterative approach of the SISYPhuS model is introduced as a three-level horizon and is illustrated in the figure above.

3.2 Preparatory phase

The first phase of the model, the preparatory phase, deals with the basic tasks which are necessary for the development of a warehouse layout. To transfer the SISYPhus model to a process-oriented project plan and to bring the goals of the model in accordance with corporate goals, such work packages as "Project management" and "Target agreement" were introduced. The methods of the project management help not only to determine the expenditure of time and resources required for the project, but also to coordinate them with the purchaser of the warehouse expansion.

The target agreement helps to formulate the aims of the warehouse expansion SMART (Biesel, 2012) and conflict-free (Lanwehr, Müller-Lindberg, & Mai, 2013). SMART aims must be specifically formulated and, therefore, clearly describe the result which has to be achieved. This future state must be measureable at the extent where the reached aim can be proven. Every aim must be assigned to a certain person, it must be realistic to be achieved, as well as time-related. To avoid contradicting aims, the method of Balance Scorecard (Kaplan & Norton, 2001) is proposed for the user of the SISYPhuS model. Conflicting aims can appear, for example, between the logistic and purchasing departments. The purchasing department would prefer to order big batches to benefit from price deductions, whereas the logistic department would go for low storage places (because of the costs for the stored goods). In this case the aims must be worked out that the optimum between the costs for goods storage and reached price deduction is reached.

3.3 Current state analysis

A storage system is an extremely complex entity consisting of the storage technology, the commissioning and the accompanying processes. It is not a rigid but a predominantly dynamic system. Goods and information move within the networks through the warehouse and are exchanged at certain points with the environment. To create an ideal design, a complex current state of the warehouse must be described accurately. This serves as the initial point for the future development of a new improved warehouse layout. The current state of a warehouse can be described by constructing a characteristic which focuses on the following three perspectives (Rouwenhorst, et al., 1999):

- storage system (Which storage technology and storage processes are involved in the material flow?);
- organization (How are the warehouse processes controlled?);
- resources (What resources are required for the storage system?).

The analysis of the existing warehouse characteristics combined with the information on the goods- and material flows, as well as space utilization and analysis of dynamic and static data, serve an important background for the subsequent phase of the model, design phase.

3.4 Design phase

With the beginning of industrialization, much attention had been paid to the topic of factory planning. This topic has been extensively discussed and has become the subject for a number of publications (Kettner, Schmidt, & Greim, 1984; Grundig, 2010; 2013). Many of the models developed to serve the purpose of factory planning are insufficiently tailored to the specific requirements of a warehouse expansion. The models for the expansion of an automated miniload warehouse do not cover the necessary calculation of the key performance indicators (e.g. the amount of moved small parts containers in the AMW). Notwithstanding this lack, the planning principles of factory planning can be adapted to the needs of a warehouse expansion. The models created for the factory planning as well as the SISYPhuS model deal with the configuration of logistical structures. Thus, the planning principles of factory design can be adapted and applied to the needs of a warehouse expansion. For the development of a warehouse expansion layout guidelines are needed to provide the planners with the necessary guidance. To this end, the planning principles by Grundig (2013) were adapted to the needs of a warehouse expansion and summarized in the following list:

1) Necessity of planning the ideal warehouse layout

   Developing the ideal warehouse layout should be done in a way that all logistic services required by the customer are met, regardless the questions of technical feasibility. While choosing the most appropriate variant, the ideal warehouse layout serves as a reference for the evaluation.

2) Variant principle

   Starting with the ideal warehouse layout, the planner has to design other alternative feasible storage layouts, which will be evaluated in the subsequent phases.

3) Integral planning

   All developed warehouse layouts depict the entire warehouse system, including the points of interaction with the environment of the warehouse.

4) Value-added analysis

   All developed warehouse layouts constitute the entire material flow in the warehouse, including the associated interfaces between internal and external production as well as the end consumer.

5) Economy

   One of the main tasks of logistics is to analyze the tension between services and costs. When evaluating the alternative warehouse layouts, the services must be compared with the costs.

3.5 Decision making phase

To allow the process model to find the most appropriate warehouse layout among various alternative warehouse layouts, a tool, comparable to a mechanical sieve, must be used. At this stage in order to evaluate different storage layouts, Rouwenhorst et al (1999) suggests to implement an evaluation phase. It is necessary to evaluate the ideal and suggested alternative design layouts with a developed catalog of criteria. The aim is to choose the version that satisfies the catalog of criteria best. In addition to the known criteria, such as area utilization of available floor space or minimal walking distances, the costs should be introduced as an evaluation criterion, which includes investment and maintenance costs. This is done with the purpose to achieve a maximal throughput with minimal investment and maintenance costs.

4 Conclusions

The SISYPhuS model is a process model which was developed in order to satisfy the interests of that part of logistic planning which deals with the expansion and optimization of the warehouse system. It describes the necessary steps to design an optimal layout for the warehouse expansion, and consists of four main phases – preparatory phase, current state analysis, design and decision making phases. Each phase is subdivided into a number of tasks which have to be successfully accomplished in order to create the final layout matching the needs of a modern warehouse system. To ensure the high quality of the layout of the warehouse expansion, an iterative approach that allows addressing the decisions to the right management levels was also implemented into the SISYPhuS model. A combination of the knowledge taken from the existing models with the ideas brought into the SISYPhuS model, is a real benefit of this study which is reflected in a possibility to keep the model rather flexible and adjustable to the needs of the warehouse expansion.

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