

## IN SEARCH OF UNIFIED WAREHOUSE DESIGNING METHOD

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**Abstract** Both scientific journals and academic books present many warehouse designing methods. This diversity shows differences in approach to designing process. This is a consequence of the fact that methods are results of authors' different points of view. A critical review of the literature proves that most of the proposed designing methods are fragmentary and their designing steps are not put in a logical order. Finally some methods seem to be functional specification rather than designing methods. Therefore it is highly desirable to achieve systematisation of existing methods, to add new facets and aspects of warehouse designing and consequently try to develop a unified method. The literature review of the problem led to a critical review of the warehouse designing methods. It is precisely described in the paper. The critical review resulted in answering the question whether to develop the new method or not.

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## 1. INTRODUCTION

On the one hand, having in mind constantly increasing globalisation, global supply chain is an important issue for many companies as it involves a company's worldwide interests rather than simply a local or national orientation. On the other hand the success of the company depends not only to global productivity but also, the smallest cells of its system. In the entire supply chain at its micro level *a warehouse* is placed. Therefore a warehouse is one of the key elements in supply chain efficiency. Material handling in a warehouse can make up to 20% - 50% of the total operating expenses, which are actually part of logistics costs, as is noticed by Tompkins, White, Bozer & Tanchoco (2010, p. 10, 442). Therefore a warehouse needs to be properly designed in case of reducing any unnecessary costs.

However, many warehouse designing methods are presented in literature, most of warehouse designs are based on *ad-hoc* insight and experience of the warehouse designer. On the one hand this is a consequence of the fact that methods are results of their authors' different points of view, on the other hand the critical review of the literature proves that most of the proposed designing methods are seems to be incomplete. "*A scientific design methodology must satisfy certain necessary conditions. First it must be able to search over a large solution space that is not limited by the experience or intuition of the designer. In other words, it must be capable of generating new alternatives that were not known before the start of the design effort. A second requirement is that the result of the design effort must be repeatable*" as it was said in Goetschalckx, McGinnis, Bodner, Govindaraj, Sharp & Huang (2002, p. 1). Here is the literature study that describes the problem in terms of the critical issues presented method.

## 2. EXISTING METHODS

As Baker & Canessa (2009, p. 425) claim, "in spite of the importance of warehousing to the customer service and cost levels of many businesses, there is currently not a comprehensive systematic method for designing warehouses." In their paper, the current literature on the overall methodology of warehouse designing is explored. They also discuss the literature on tools and techniques used for specific areas of warehouse designing analysis. They also recapitulate that over the years some typical and very general terms are proclaimed. One of the proclamations says: "a sound theoretical basis for a warehouse design methodology still seems to be lacking" (Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel & Zijm, 2000, p. 515) and the other one is more strictly: "a comprehensive and science-based methodology for the overall design of warehousing systems does not appear to exist" (Goetschalckx, McGinnis, Bodner, Govindaraj, Sharp & Huang,

2002, p. 1). While studying the literature of the warehouse designing problem, it is hard not to admit that mentioned summaries are undeniably right.

As far as warehouses designing methods are concerned there were identified 16 designing methods listed in: Kostrzewski, 2012b, pp. 535-536.

The critical review of the literature proved that most of the proposed designing methods are fragmentary and too vague, too general – e.g. method of Firth, Apple, Denham, Hall, Inglis & Saipie (1988) consists of 5 designing steps only: “*identify the warehouse functions, gather data and make projections, develop alternative methods, combine functional alternatives into single system, select the total system*”. Similar problem, in opinion of this paper’s author, concerns methods by Hatton (1990), Govindaraj, Blanco, Bodner, Goetschalckx, McGinnis & Sharp (2000) and Bodner (2002).

Some of designing steps in few of 16 methods are not in logical order. In method by Apple (1977), a kind of dissonance between successive of designing steps is recognized. Apple’s method consists of designing steps such as “*procure data, analyze data, design processes, plan material flow pattern, calculate equipment requirements, plan individual work areas, select material handling equipment, determine storage requirements, plan service and auxiliary activities, determine space requirements, allocate activity areas to total space, construct the master layout*.” As the example, it can be said that the “*plan individual work areas*” designing step should occur before the “*plan material flow pattern*” designing step. It is impossible to present a plan for a flow of materials without previously prepared layout of a warehouse. The same problem concerns the designing steps: “*determine storage requirements*” and “*allocate activity areas to total space*.” They should be carried out before step “*plan material flow pattern*” because of the similar nature. The problem with the order seems to exist also in case of methods by Oxley (1994) and Rushton, Oxley & Croucher (2000). Oxley’s method consists of designing steps such as: “*define system requirements, define and obtain data, analyze data, establish unit loads to be used, determine operating procedures and methods, consider equipment types & characteristics, calculate equipment capacities and quantities, define services & ancillary operations, prepare possible layouts, evaluate and assess, identify the preferred design*”. In case of method by Oxley, the “*determine operating procedures and methods*” designing step should be followed by “*define services and ancillary operations*”. Method by Rushton, Oxley & Croucher (2000) consists of designing steps listed here: “*define system requirements and design constraints, define and obtain data, analyze data, establish unit loads to be used, postulate basic operations and methods, consider possible equipment types, calculate equipment quantities, calculate staffing levels, prepare possible building and site layouts, evaluate the design against requirements, identify the preferred design*.” About method by Rushton, Oxley & Croucher (2000), it is believed that the “*prepare possible building and site layouts*” designing step should occur before the “*calculate equipment quantities*” designing step. Determining the number of vehicles and required equipment includes distance travelled by the means

of transport between the points of origin and destination points. These distances are identifiable on a layout of a building.

There are also some other defects of designing methods, for example: lack of a possibility of order-picking area designing – *e.g.* methods by Heskett, Glaskowsky & Ivie (1973), Hassan (2002) – and, what is serious, a fact that methods do not treat the whole designing problem. As far as method by Heskett, Glaskowsky & Ivie (1973) is concerned, none of designing steps of this method does not indicate any point that there should be implemented dimensioning of warehouse processes. And there is no proposal for the calculation of capital investment, operating cost and other economic criteria for project evaluation. Furthermore, the method proposed by Apple (1977) does not consider the quantitative parameters such as: employment quantity, a number of vehicles and warehouse equipment *et cetera*. The method is limited to the designing of a layout and a selection of a storage infrastructure. Oxley's (1994) method ignores the problems related to a number of employees. However, in case of a method developed by Rouwenhorst (2000), considering the sequence of consecutive designing steps is right, the disadvantage of the method is that it is limited to a layout arrangement and selection of a warehouse equipment. In this method there are no designing steps connected to a determination of the quantitative parameters, and any project evaluation procedures. At the same time, method by Waters (2003) takes into account a layout and proper infrastructure only. There is no question of means of transport, and even less about technical and operating quantitative parameters.

And at last, some methods seem to be functional specification rather than designing methods. The method developed by Mulcahy (1994) is that type. The aim of a functional specification is to prepare the plan and determine the spatial storage equipment. A functional specification is the documentation that describes the requested behaviour of an engineering system not a warehouse project itself.

Differentiated approach of each of individual authors or co-authors groups can often induce consternation, as mentioned above. However, this is not tantamount saying that these methods are incorrect. The problem, however, is the fact that mentioned methods seem to be incomplete in their expressions. This does not mean the advantages of these methods are not observed and noted. There are parts of these methods, which were included into a new method presented at the end of this statement, *e.g.* an idea of simulation while designing process. This is set out in basic framework of steps of Rowley (2000). In the former publication, the usage of computer simulation is included. It is to test the impact of different volume throughputs and to identify the consequences on the rest of the supply chain.

Following the positive aspects of critical review of the warehouse designing methods, the most comprehensive investigation was done by Fijalkowski (1995). His method contains many aspects, such as: technological, economic and organizational. There are not only aspects related to storage technology, examining the components of a project in terms of functional and spatial. Apart from them, it also shows the organizational issues, financial aspects, and insists on a comprehensive assessment stage for all the solution's variants. In none of other methods, except

for the method according to Korzen (1998) has been proposed such a rich compilation of individual elements of the designing as in method by Fijalkowski (1995). Due to the complexity of the Fijalkowski's warehouses designing method it was decided to re-done this method and to add some other components. That means method by Fijalkowski was a main base for described research. However, changes in relation to the basic method have been proposed.

### 3. NEW "UNIFIED" METHOD PROPOSAL

As a result of the review of the literature on a warehouse designing, it is concluded that relatively few studies refer to the designing process. Due to the high cost of warehouse designing projects and transport equipment, and significant consequences of incorrect dimensioning or oversizing it, more comprehensive and systematic method is required. Author of this review has presented research on that matter before, but under some circumstances the decision connected to changes in the previous ideas was made. The new "unified" warehouse designing method was presented partly in conferences proceedings as in Kostrzewski (2012a), as papers in journals such as: Kostrzewski (2012b, 2012c) and as chapter of monograph in Kostrzewski (2011). That was before the rearrangements of the method. The next step of the method evolution is presented in a few words below. At the same time it is required to keep in mind that it is impossible to devise a method that will be used for each of the warehouse projects. Each project is a separate type of issue, and in fact is unique. That is the reason why the word "unified" is surrounded by quotation marks.

The previous method for warehouses (warehouse) designing consisted of three phases: task defining, solution designing, and solution evaluation. The method was limited to gathering data, engineering and technology project, not taking into account the implementation phase of the project. It was decided to make the re-engagements of the previous idea. One of them was to include a simulation idea as a part of implementation process. Another were: to make some changes, to add new designing steps, to organize them properly, to arrange as clearly as possible to make the method "unified" one.

The "unified" warehouse designing method is still evolving. Notwithstanding the general outline of the method remain unchanged, author decided not only to publish it in the form presented in Fig. 1., but also to begin to use in its current form. Additionally, the designing software basing on the part of unified designing method was prepared. It allows preparing many variants of a warehouse project in a relatively short time. Since the software was presented and discussed in Kostrzewski (2011, 2012b), it is not described here.

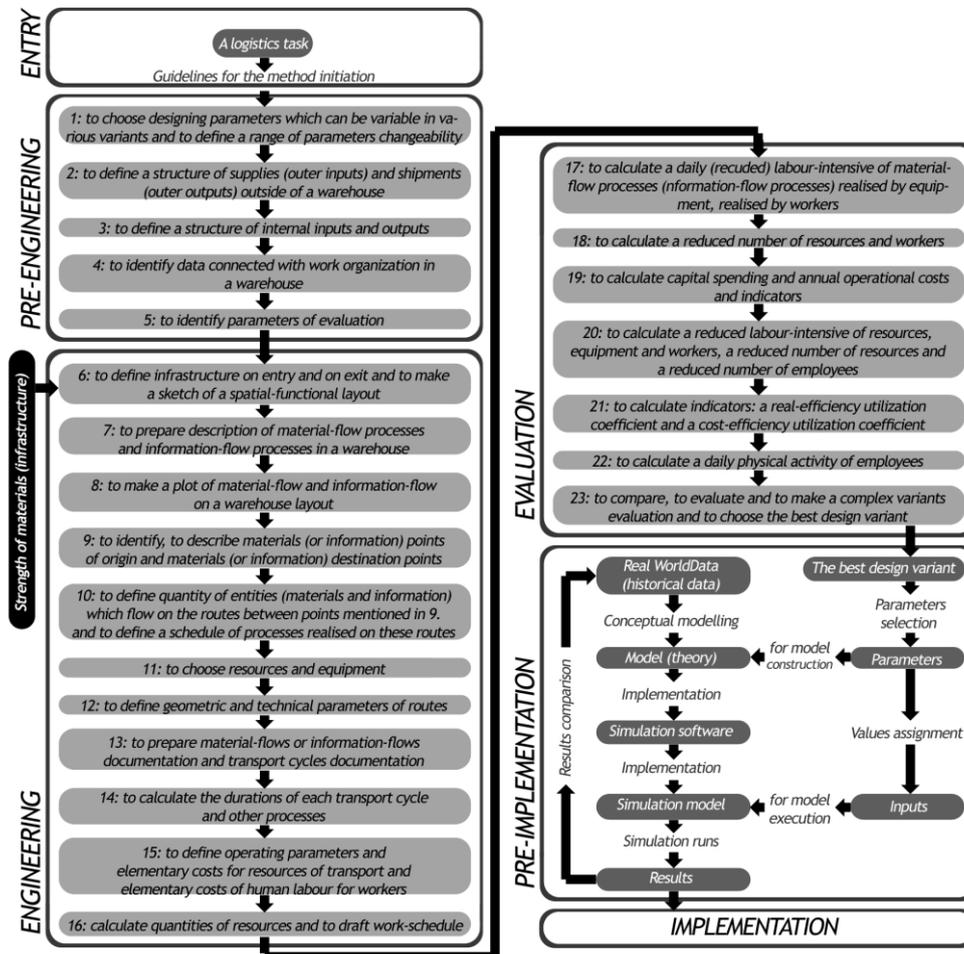


Fig. 1 Scheme of unified warehouse designing method

The *Entry* phase is generally connected to logistics task defining. It is gathering data and analysis. It would be said that the most important aspect of a warehouse design is data collection. The correctness of this pre-designing phase determines the effectiveness of the designed warehouse. It must be known how much stock-keeping units will expand. Design specification of stock keeping units such as the size, weight or cube of its *et cetera* must be declared also. Their receiving characteristics, shipping characteristics and storage characteristics also must be known. In case of receiving characteristics and shipping characteristics must be known quantities, frequency and periodicity of them both and such a fact like a warehouse has to deal

with full pallets or full truckloads of goods on receiving and shipping or not. The *Entry* phase gives guidelines for the next phase, which is *Pre-engineering* one.

The *Pre-engineering* phase consists of five designing steps which realization generally depends on data gathered in the previous phase. Extremely important is realisation of the designing step No. 3. It is because many quantitative parameters calculated in the *Engineering* phase depend on it.

As the *Evaluation* phase is concerned, it consists of few designing steps, which give the opportunity to make an evaluation of every variant of warehouse design. Although many evaluation parameters exist, what is important, not every of them must be taken into consideration. It depends on aims, which were defined in *Pre-engineering* phase. Evaluation parameters are described in Fijalkowski (1995, 2002, 2008) and Kostrzewski (2007).

It was repeatedly alluded the importance of evaluating a designed warehouse through the use of simulation studies next to an analytical evaluation. The *Pre-implementation* phase is to introduce the simulation idea into a warehouse designing. The usage of planning and simulation models can help to identify optimisation potential in terms of throughput, cycle times, transporters (and vehicles) utilization or warehousing equipment's and infrastructure's utilization *et cetera*. Simulation, even a discrete-event one, can help to map in details the dynamic behaviour of a complex system. Scenarios can be built, either by simulation or other modelling, to consider a series of different situations in which the flexibility of the design can be tested. These scenarios may include for example alternative growth forecasts, changes in order profiles, and abnormal peak requirements. More information about simulation model(s) constructing can be found in: Anon. (2006, 2009), Bangsow (2010, 2012), Kostrzewski (2007).

#### 4. CONCLUSION

The paper attempts to articulate the ongoing work on a unified approach to the problem of a warehouse designing. The problem still remains open. Any such attempt is a contribution to the achievement of the fundamental, which is to harmonize the approach to the problem, which in this case is “unified warehouse designing method”. It can be proclaimed that a comprehensive warehouse designing method thus appears to be a goal of author’s research that is still far from being achieved. A debate on the precise steps, as the activities in the designing process grouped together in various combinations, is still needed. Similarly, there is needed a further debate concerning the sequence of these designing steps, as warehouse design tends to be an iterative, rather than a sequential, process with feedbacks that concern some of designing steps. Author does not exclude further changes in the method, which can manifest itself as a result of collaboration with leading experts in warehouse designing. It must be remembered that a good warehouse design depends on how well a designer

understand client business. Unless a warehouse design meets all of company's unique necessities, both short-term and long-term planning horizon, the best "state of the art" facility may not solve client real requirements.

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## **BIOGRAPHICAL NOTES**

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