THE USE OF VIRTUAL FACTORY CONCEPTS AND MODELS FOR FACILITATING LOGISTIC SYSTEMS AND OPERATIONS

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Abstract

Creating a virtual model takes an individual approach. A company's structure and organization must always be taken into account. The aim of this publication is to describe and analyze virtual factory concepts and models and their implementation as a means of improving company's logistics and operation. The publication also analyses key factors that should be considered in order to choose optimal software package. Different methods and stages of creating a virtual factory model are presented. The interrelation between all parts of the model, considering internal and external aspects of company's activity, was described and analyzed. Also, different ways of combining virtual factory models with efficient supply chains between companies were presented. The solution provided is a basis for creating a corporation and building an integrated supply chain management system, which is characterized by an integral set of market principles. Integrated supply chain management highlights the connection between the aims of company's activity and those of supply chain. Virtual reality remains flexible and can be adapted to changing circumstances.

Keywords: Virtual Factory (VF), Virtual Reality (VR), Virtual Logistics, Virtual Production, model VF

1. INTRODUCTION

Adjusting company's activity to customer needs enhances its competitiveness and strengthens business' position as a producer. Continually changing market of customer demand makes it inevitable for companies to adapt to such changes by upgrading and modernizing their manufacturing processes and adapting logistic solutions to the changing conditions. Large companies like Siemens AG, Daimler AG were among the first to implement the conception of VF. There are many definitions for the term "Virtual Factory" (VF) which in literature also appears as „Digitale Fabrik "(DIFA) [4]. In addition, the literature review [3] offers three definitions of DIFA. Large companies like Siemens AG, Daimler AG were among the first to implement the conception of VF. There are many definitions for the term "Virtual Factory" (VF) which in literature also appears as „Digitale Fabrik "(DIFA) [4]. Literature [3] offers three definitions of DIFA. Danfang Chen, Benjamin Hirsch, Engelbert Westkämper take Digitale Fabrik's meaning as a reflection of an existing factory with possibility to represent it. Javier Silvestre-Blanes, Daniel Morris, Michael Schenk treated Digitale Fabrik as a conception embracing digital models and methods and the same ensures the possibility of the initial planning of a factory and production prior to shifting it into a real enterprise. Uwe Bracht, Christian Eckert developed the idea by adding that Digitale Fabrik includes the process of a product digital development and perfecting of all the basic factory processes and resources linked with a product. These definitions are close to those of „Digitale Fabrik" committee composed of the groups of Modeling and Simulation, of the Association of German Engineers (Verein Deutscher Ingenieure- VDI), working in the area of product digital development by the means of digital models and tools to improve the real enterprise [4]. The German VDI guideline VDI 4449 defines as follows: „The Digital Factory is the generic term for a comprehensive network of digital models, methods and tools - among others simulation and three dimensional visualizations - which are integrated by an integral data management. Its goal is the holistic planning, evaluation and continuous improvement of all relevant structures, processes and resources of the real factory in connection with the product" [13].

The Definition of a model in the German VDI guideline VDI 3633: "A model is a simplified replica of a planned or real system with its processes in another system. It differs from the original in important properties only within specified tolerance levels" [1]. Another definition of a model, which I would suggest, virtual model is a digital model integrated through complex data management, 3D modelling, visualization and simulation. It enables to obtain optimal management and control solutions, as well as considerably contributes to the efficient activity of a real-time factory. The essential role of virtual factory model is adequate responding to the changes in company's activity through comprehensive planning, risk assessment, improving virtual model processes and resources and implementing innovative solutions for a real company. There are numerous options as far as designing and implementing a virtual model is concerned. [8] There is also a wide selection of tools in the form of software packages, which facilitates accurate virtual model creation and offers efficient solutions for any kind of problems that the company might come across.

The key aspects that should be analyzed when choosing a software package are:

- compatibility with company's aims and priorities, what software will help achieve these aims and realize priorities;
- versatility; what software performs multiple functions and replaces other software packages as a versatile tool;
- the capacity of software to project individual processes;
- compatibility with company's needs and expectations;
- reasonable price; whether the software is worth its price

Creating a virtual factory is a complex process that requires prompt responding to any changes within company. Implementation of innovative logistic and manufacturing solutions should be planned with not only one particular process in mind, but all groups of processes should be taken into consideration. Their implementation should be preceded by a thorough and accurate financial analysis of the whole investment [9].

2. VIRTUAL MODEL AS A TOOL FOR ESTABLISHING INNOVATIVE BUSINESS

One of the key elements that determine company's success is advantage over competitors. Using virtual reality, we can identify downsides and shortcomings of real business. It helps to notice any drawbacks in logistic and manufacturing planning, lack of comprehensive activities, lack of optimization and other weak points (e.g. inefficient manufacturing plans, overloading machines, which imposes limits on their capacity, inefficient logistic planning, etc.). Such an analysis allows us to identify company's strategic aims. That, in turn, brings about the changes that lead to company's development. Efficient planning and developing new lines of action. In order to facilitate communication within the scope of design principles, it is advisable to start with a single process' reorganization and then proceed to combine it with other units until an entire virtual model is created. Taking into account a great variety of company profiles, it must be emphasized that every type of company needs an individual approach when it comes to designing their virtual factory. That is what makes the whole task complex. Companies need to organize their own 3D object libraries, upgrade their computer software to be coherent with a virtual factory software of their choice and introduce many other changes on different levels. All of them are time consuming and require financial resources [2]. The complexity is also present in a constantly changing technical documentation of a plant with coinciding lack of the VF model automatic change. Model VF does not efficiently meet the requirements to be used for plant rebuilding purposes. However, the domination of 2D and 3D technical model of architectonic documentation is observed. Uniting those criteria would result in finding a multiple tool for parallel work of different units. In example, it would give the possibility to manage the logistic process as a single unit of VF model, and the 3D model of a warehouse, created precisely according to technical documentation, to be used for the purposes of rebuilding

of a plant. Such model would also be able to function as 2D model, which avails elasticity in the change of a warehouse format in the real-time. (**Figure 1**).

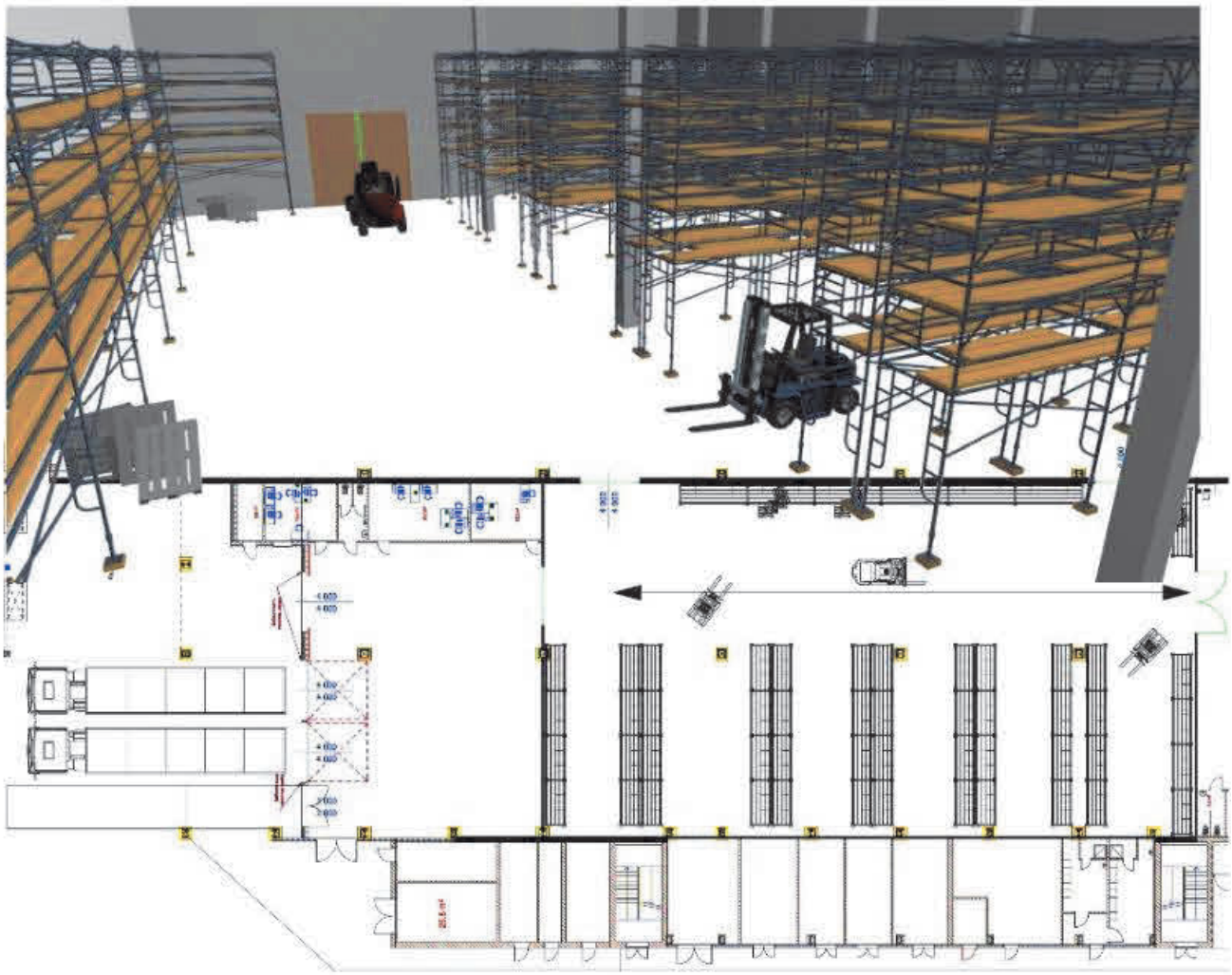

Figure 1 Creation of a logistic unit (Source: own elaboration)

A rapid exchange of data within technical teams, effective Communications In the area of project rules remains an important aspect. Such single units of FV model gathered together compose a precise model, which is the VF model comprising external and internal functioning of the entire enterprises. The methods used in the creation of VF model, which should be indicated are:

- method of planning;
- computer simulation;[5]
- visualization;
- animation;
- photogrammetry;
- processing of statistic data;
- processes modeling (BPMN, SADT, UML, Data Flow Diagrams, IDEF0) [11].

Joined methods, like integration of new technological solutions with the planning of installation and production movement flows planning, can also be used. While forming of VF models, the necessary thing is the use of the following key elements in form of models:

- DiFoR Model (Digital Factory Operating Reference), based on Tyree key elements "model- method- system" [12].
- SCM Model (Supply Chain Operation Reference-Model), supply chain reference model;
- 2D graphic model, based on planning of a plant production space;
- 3D graphic model, based on detailing of CAD 3D models creation;
- Computer simulation model;
- Process model, based on modeling of a plant business processes;
- Analysis model, based on three key elements: „interpretation-decision- prognosis";
- Standardization, structuring model of documentation (technical, legal, company, administrative, commercial, etc.).

Another way of models classification exists:

- Graphic model (2D and 3D model drawing);
- Analytical model (mathematic processing of statistical data);
- Numeric model (simulation model).

Usage of an advanced analytical tool allows to acquire input data of factory logistic In the shape of charts, statistic data, analysis of bottle necks. Relations like worker - worker, worker - machine, machine - machine, worker - IT system, largely influence process changes of a production plant. This process results in the appearance of new business models, which ensure availability of information necessary for quick creation of logistic systems digital models and it enables inspection of systems' characteristics and optimization of their efficiency. For planning of a plant logistics, virtual environment has to contain 2D and 3D graphic models, simulation models and analytical models of data processing [7]. In the process of building a virtual model, operations are visualized using 2D and 3D, and simulation serves as a tool to display the data necessary for optimal usage of resources and flow of materials. Such a rational attitude allows quick creation of dynamic storage processes, as well as taking better decisions and logistic operations [6].

3. VIRTUAL FACTORY MODELS IN INTER-CORPORATE LOGISTIC PRINCIPLES

Choosing the adequate strategic direction is of crucial importance for company development. Setting out the right direction in a real time company entails constant and flexible updates of logistics processes in Virtual Factory model. Company's logistics is usually focused on its internal and external changes. While introducing any changes, it must be remembered that a final stage of any process must match the initial stage of a next one. All the logistic processes must form a consistent unity and complementary adjuncts must not break it. Order fulfilment is subject to changes and is usually associated with reorganization of logistic processes in a factory. However, whenever it becomes necessary to make any changes to the flow of goods management, there is a risk that they may be not delivered to a producer on time. Besides, there might occur some disruptions at semi-finished products level. That implies likelihood of delays in order processing. It is worth to notice how Virtual Factory model functions in multi-factory and multinational corporations. Corporations consist of independent units (production plants) that are joined to form one unity. This unity faces the challenge of creating inter-corporate logistics and supply chain that connect all units in an organized way. Also, effective cooperation with other logistic centers is a key factor. The final link in a supply chain is a consumer and the priority remains to ensure a quality product is delivered to them in a timely and efficient manner (**Figure 2**).

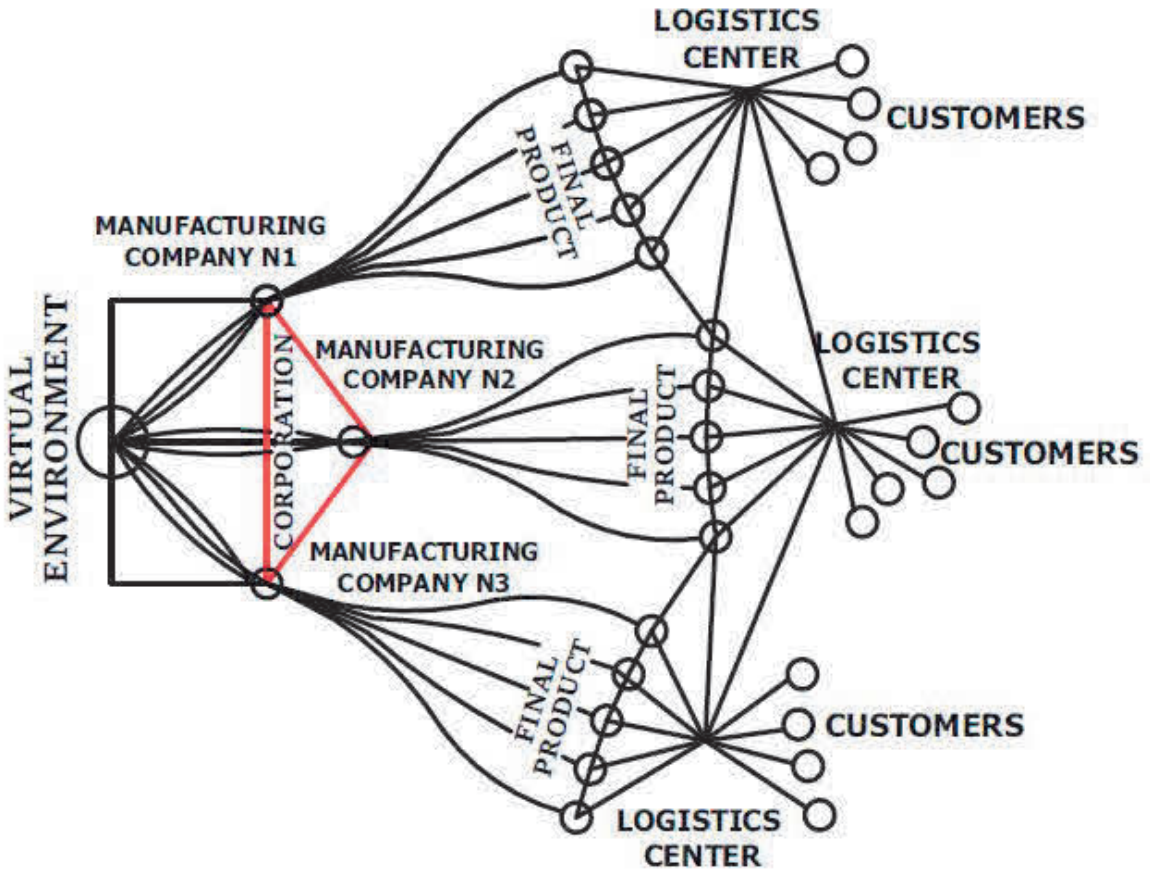

Figure 2 Supply chain of final product in inter-corporate logistics
(source: own research)

Inter-corporate logistics consists in the flow of goods between factories, where the circulation of supplies and half-finished products is subject to a flexible production schedule. The first step is to identify final production output and pass that information to a logistics hub, which is a spatial-dimension facility that has its own organization system and infrastructure. These facilities make it possible for independent companies to transfer, store and track the flow of goods all the way from producers to consumers. Responsibility for internal supply chain development is one of the crucial tasks for a company. Supply chain connects different production plants in order to enhance the value added in the whole chain, benefiting units at every stage. That kind of chain might be defined as mega-process, that is, a total of activities, from designing and manufacturing a product to the point of delivering it to a consumer. Each mega-process goes through every single unit of Virtual Factory model. Main processes might be repeated even several dozens of times. Each process can be described by a number of characteristics. Virtual Factory model speeds up order processing. Data exchange is conducted in a uniform virtual environment, which facilitates clear and effective communication. It should be noticed that Virtual Factory model depends not only on the type of products manufactured in the factory, but also on the way they are made to meet consumers specific requirements. There might be even several dozens of such ways - methods, which makes each process in the model quite complex. Both semi-finished product and raw material logistics are related to final product inter-factory logistics. The more factories within a corporation, the more coherent all processes should be. If that becomes the case, the supply chain of final product develops and is reinforced (**Figure 3**). In such complex supply chains, Virtual Factory model considerably contributes to fast transfer of data and information, which optimizes logistic processes at all levels and reduces expenses. Efficient and effective supply chain management considerably improves customer service. It helps to build

customer trust through ensuring prompt and appropriate order processing, timely deliveries and reducing the number of complaints.

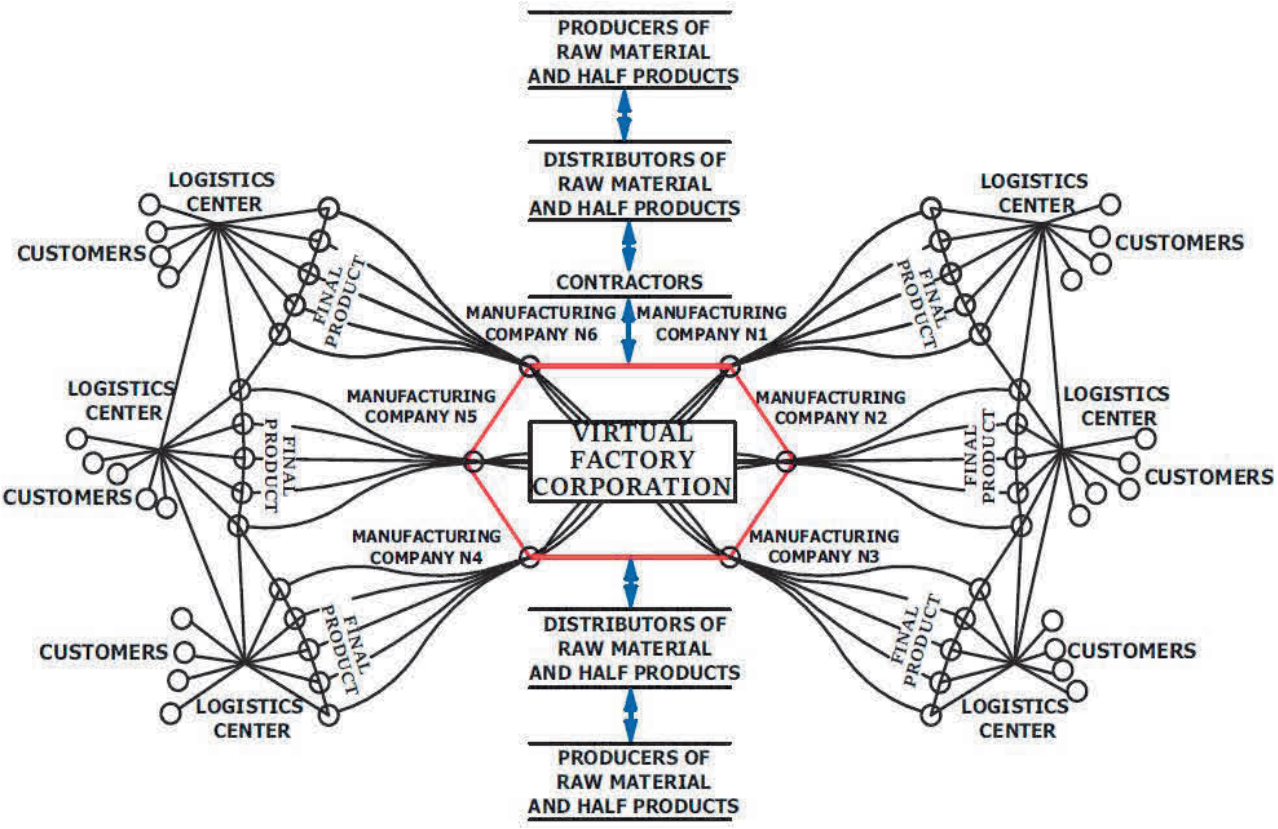

Figure 3 Integrated supply chain of final product in internal company logistics
(source: own research)

While designing a supply chain it is important to consider company's localization. Supply chain is influenced by entrance / exit locations to / from each point in integrated structure. As a result, we receive networks that consist of groups of trails and factories connected through these trails. Virtual factory model allows for creating and simulating logistic systems and analyzing logistics at all levels of real time factory designing. It brings about the optimization of the whole supply chain, including global logistics centers, local factories and specific logistic operations [2].

4. CONCLUSIONS

This paper describes the specificity of real-time factory functioning on the basis of Virtual Factory model. The use of Virtual Factory models improves logistic operations, reduces raw material expenses and shortens delivery time, in case of both semi-finished and final products. Virtual Factory models should be adjusted to company profiles; therefore individual approach is required. Companies need to create their own virtual libraries, ensure compatibility between all their programs and adapt their management strategies.[2]. There must be a correlation between company's strategy and Virtual Factory concept. The latter ones must also form a unity. There are different kinds of Virtual Factory models because they must be compatible with individual businesses. A Virtual Factory model must match company's specific internal logistics. Extending a company or its operations to corporation level makes its supply chain complex. While creating a Virtual Factory model, it is important to consider and take into account all aspects of company's activity. Only then can we expect tangible results: company becomes more efficient, economically viable and better organized.

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