Virtual Engineering in investment goods industry - Potentials and application concepts

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Abstract

This contribution deals with an application concept of Virtual Engineering (VE). Therefore requirements of cooperative product development and information and communication technology towards Virtual Engineering are described. An approach to introduce VE is presented.

Keywords

Virtual Engineering, Investment Goods Industry, Application Concepts, System Architecture, Communication Technology, Information Technology, Cooperative Product Development

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1 INTRODUCTION

The target markets of the companies are characterized by increasing dynamics. The pressure to shorten product life cycles and product delivery times continues to grow, even though companies have already applied such approaches like Simultaneous Engineering and process orientation with great success, in order to respond market and customer demands (figure 1).

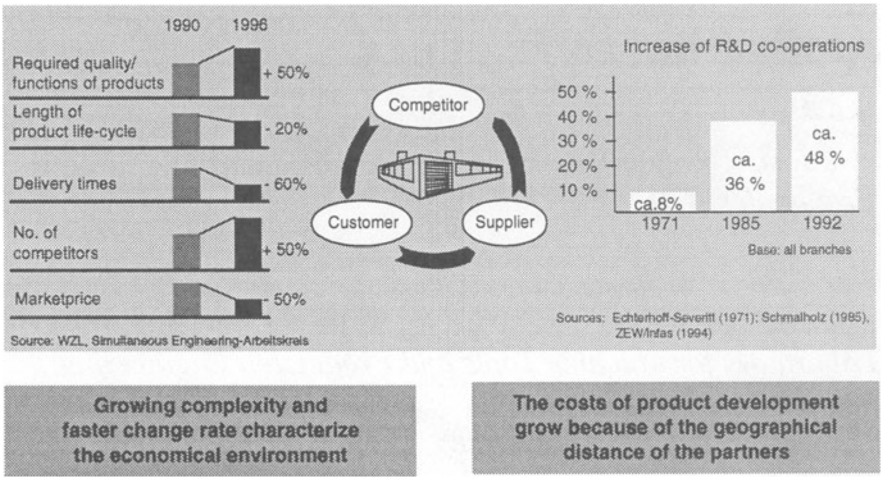

Figure 1 Changes in companies.

Technology has become so sophisticated, broad and expensive that even the largest companies cannot afford to manage all themselves. In order to conquer this situation effectively, companies concentrate on their core competencies and bundle these for rapid product development of innovative products within development cooperations (Pfeiffer, 1994; Eversheim, 1997). Organizational and technical border conditions which are the basis of Virtual Engineering (VE) need to be considered in order to realize cooperative product development.

This paper addresses both issues of Virtual Engineering in the investment goods industry, the end-user point of view with some expectations concerning usability, and the technology point of view, discussing necessary core technologies.

2 VIRTUAL ENGINEERING

Virtual Engineering is an solution to the situation described above. The actual research activities in the field of information and communication technology lead to short intervals of technological innovations. A special interest can be found in the evolution of applications supporting simulation and visualization of complex interactions in early states of the product design process so that the various aspects of product could be analyzed and optimized. In this context Virtual Engineering allows the design review of products on basis of CAD-data. Even process planing, production system planing and complex production facilities could be simulated, visualized and evaluated by applying Virtual Engineering Technologies (figure 2). 50% of all graphical 3D-simulations are used in product development, e.g. for design, dimensioning or digital mock-up. The amount of process planing is 23%, and production planing comes to 24%. In addition, there is also a focus on the design of innovative information and communication technology to bridge the possible geographical distances between partners in a distributed product development.

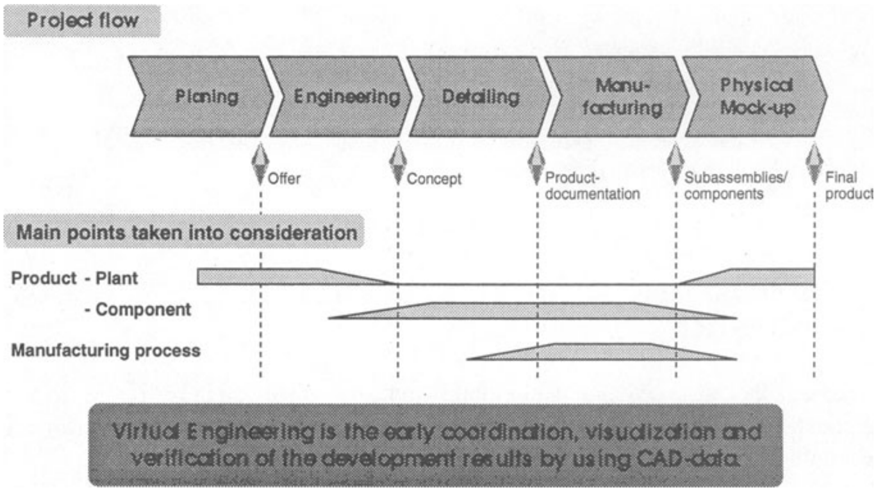

Figure 2 Virtual Engineering as a solution.

Taking these aspects into account a concept of Virtual Engineering was developed to support the network integration of cooperating industrial enterprises. The essence of this integration is the development of technologies for communication, cooperation and coordination tasks. These 3C-Technologies build up the basis for a Virtual Engineering-Environment, and include several demands which influence the concept of VE. Nowadays the product development is divided into several tasks related to development competence of each partner. Process chains becomes more and more integrated and interdisciplinary. Apart from these organizational aspects various EDP-systems are used in product development of the partner companies (figure 3).

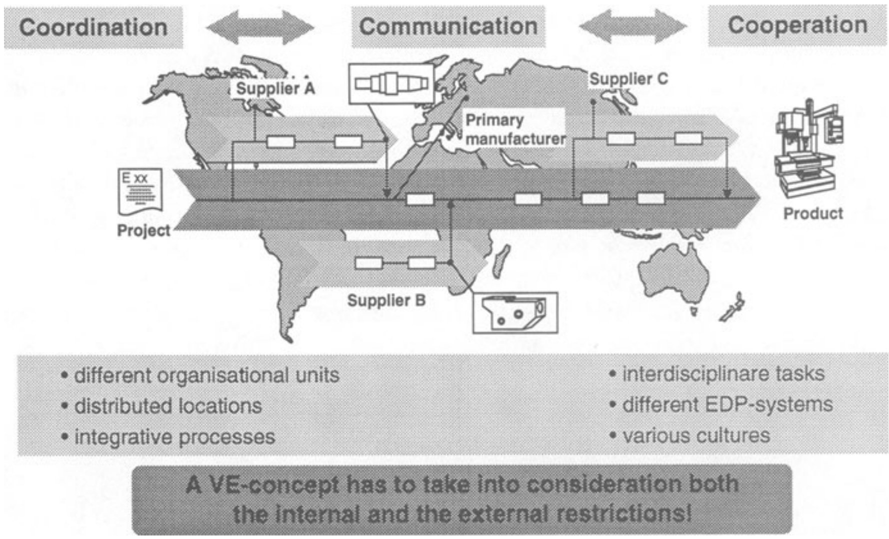

Figure 3 Aspects of Virtual Engineering.

3 REQUIREMENTS AND GOALS OF THE INVESTMENT GOODS INDUSTRY

Whereas the aircraft and automobile industry have already realized VE-applications in a great number of applications in the last years, the usage of this technology in the machine building industry is just at the beginning.
The reason for such a delay in using the new technology is caused by some structural boundary conditions in the investment goods industry, for example:

- small batch sizes (because of the great number of specific customer solutions),
- mostly small planning staff and small information technology departments especially in small and medium enterprises (SME), and
- limited know how of employees in this field and the fear towards new technology.

In contrast, the enterprises of the investment goods industry serve a market that requires the use of VE in increasing amount. In detail, the following reasons for the demand can be mentioned (Eversheim, 1996):

- high product complexity (especially a great number of functional correlation between separate product components),
- rising integration of mechanic, electric, electronic and software functions,
- customized construction,
- rising cost and time pressure, which shall be compensated by reducing the physical models and by optimizing the entire product design process in consideration of existing restrictions and

- increasing sales volume.

Therefore the main goal of the activities in Virtual Engineering for the investment goods industry is to point out possible application fields and potentials in the process chain „Technical Order Processing".

4 MODULES OF VIRTUAL ENGINEERING CONCEPTS

The implementation of Virtual Engineering is proceeded with three elements, that are the organisation inside enterprise, the business processes of the involved development partners and the computer based infrastructure. These are fundamental requirements, which have to be fulfilled by a Virtual Engineering Environment.

4.1 Organisation inside the enterprise

Activities and processes in the order processing are represented by a process analysis. This method creates transparency, and allows evaluation of reorganization measures by linking resource consumption with processes (Pfeiffer, 1994; Eversheim, 1995 and 1996). Besides this, weak-points concerning interfaces, leading time or personnel could be identified. On basis of these results conclusions can be drawn to the steps which require to be taken in order to improve the situation regarding the application of VE.

A Design Structure Matrix can be used in order to analyze interdependencies and lacks of information. Thereby planning processes can be structured and time-related supply of information can be optimized (figure 4).

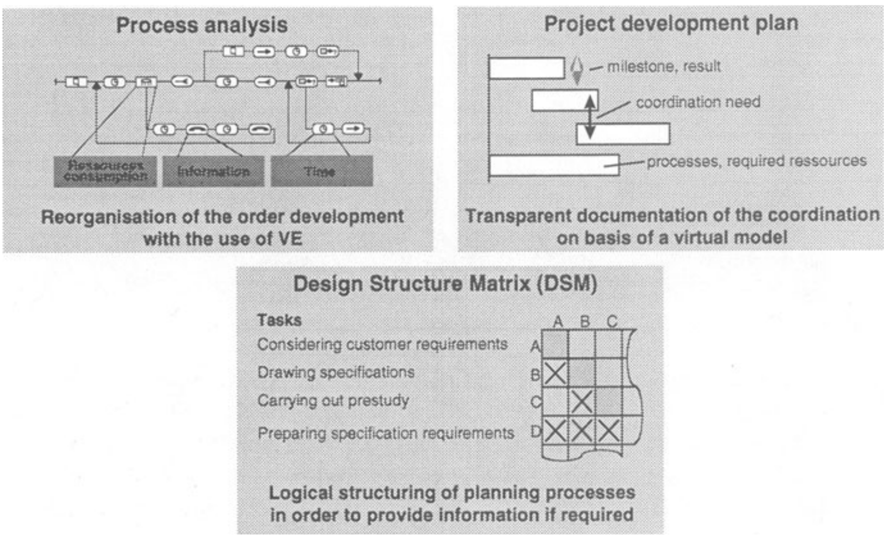

Figure 4 Organisation inside the enterprise.

On the basis of a project development plan the whole exchange of relevant information in the product development process can be coordinated throughout the enterprise completely. In addition to activities it contains milestones, deliverables and responsibilities. This instrument is an organizational framework that allows all relevant departments to contribute to decision making in early states of product and process design on basis of a virtual product.

4.2 Business processes of the involved development partners

As a result of the rising complexity of products offered by the investment goods industry, the simulation and visualization of complex correlation is getting more and more important (Eversheim, 1997). The high efficiency of offered products and the customer specific orientation of these products make it necessary to integrate the multiplex correlation among the separate product components (mechanics, electronics, software) in the engineering process as early and capacious as possible. Therefore it is necessary to inquire the latest innovative solutions by focusing on the profit for an improvement of the competitiveness in international markets (figure 5).

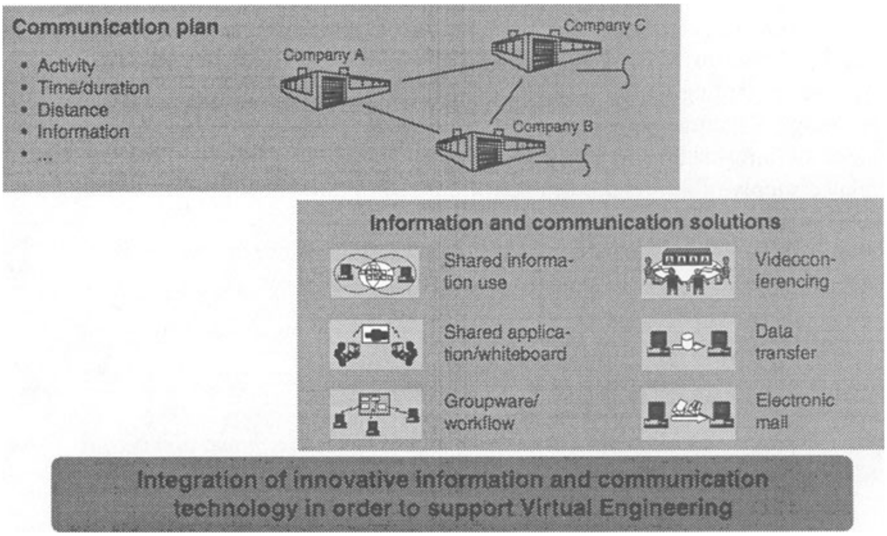

Figure 5 Business processes of the involved development partners

Within the structuring of development projects a compromise between the reduction of the development time and minimization of the coordination must be found in (Eversheim, 1997). A communication plan supports the operational cooperation between the developers of the partner companies in order to avoid the duplication of work. It is expedient to apply the methods of simultaneous engineering on an inter-company basis. The communication plan creates transparency concerning existing operational activities. Communication partners, distance, intensity and type of the respective coordination are described and identified so that communication and information technologies (e.g. Telecooperation) can be assigned according to the requirements (figure 5).

4.3 Architecture of an Virtual Engineering Environment

In order to fulfill the requirements stated above, an innovative software architecture is needed. Based on standard client-server concepts (Jasnoch, 1996; Cleetus, 1993), a distributed environment has to be set-up on a heterogeneous computing platform. The software architecture is used as an enabling technology, to establish and implement the required services from the Virtual Engineering Environment. The core of the architecture is the VE-Bus acting as a kind of middleware within the architecture. By providing the necessary communication technologies, the bus offers different coupling technologies for the modules as well.

The next core component is the product data management system, which is based on top of a distributed, object-oriented data base system. The product data management system provides all services necessary to deal with data in a well defined manner. Thus, it uses the services offered by the data base system to enable high-level control mechanisms like concurrency control and object versioning (more services are defined in Jasnoch, 1996). Furthermore, it provides all functionalities which are necessary to implement services like workflow management.

A modern architecture must provide a strategy to support the "classical" software in the same way as it supports the "modern" internet based software. By providing a concept for coupling both parts together, based on the product data management and the communication side, the architecture is able to solve the requirements of virtual engineering, especially in the field of performance and flexibility. The first topic is typically solved by specialized applications based on the programming language C or C++. Nowadays, the second topic is often solved by using the internet technology in combination with the appropriate programming language called Java.

In Figure 6, an overview of the possible modules needed in a virtual engineering environment is shown on top of the VE-bus. The specialization is mainly needed by the visualization software, which needs direct access to all resources of a computer in order to provide the performance. Recapitulating the two major phases in terms of the visualization, there is a 2D user interface needed to set-up the scenario, select the relevant product part and provide functionality for the "assembly" of the scenario, thus combining geometry with behaviour of the product like kinematics. To perform these functionalities, a wide variety of modules in areas like format converter, different modellers, semantic descriptions, and special graphic algorithms are present. In addition, the 3D user interface provides all necessary functionality to enable the immersive examination of the virtual scene. The terms 2D and 3D does not refer to the models or the geometry, but it is used to distinguish the way of presentation; a regular 2 dimensional presentation or a stereoscopic 3 dimensional presentation.

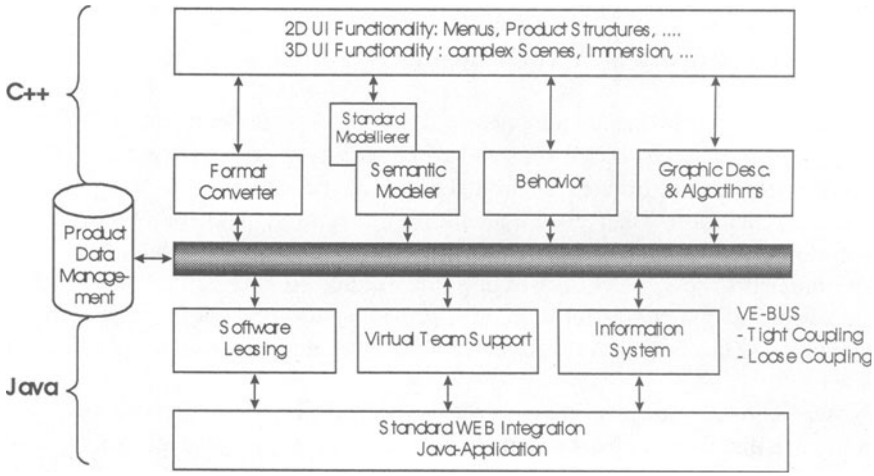

Figure 6 The logical architecture

The lower part in figure 6 mainly presents the part of dynamic, distributed information which is not as time-critical as the geometric side. Here information systems take place, with a special focus on cross-platform and distribution aspects. To support the inter-enterprise concept and to integrate into the companies intranet, this side take advantage of the flexibility and platform independence of Java and the WEB-technology at all (Jasnoch, 1998 and Franke, 1997).

5 APPLICATIONS OF VIRTUAL ENGINEERING

Based on the architecture shown in the previous chapter, applications were developed fitting to the mission of virtual engineering. The applications cover most of the aspects discussed above. As examples, two of them are introduced in this section to give an impression, how these applications are designed to help engineers in their daily work. A special emphasis of the application is on the area of computer graphics.

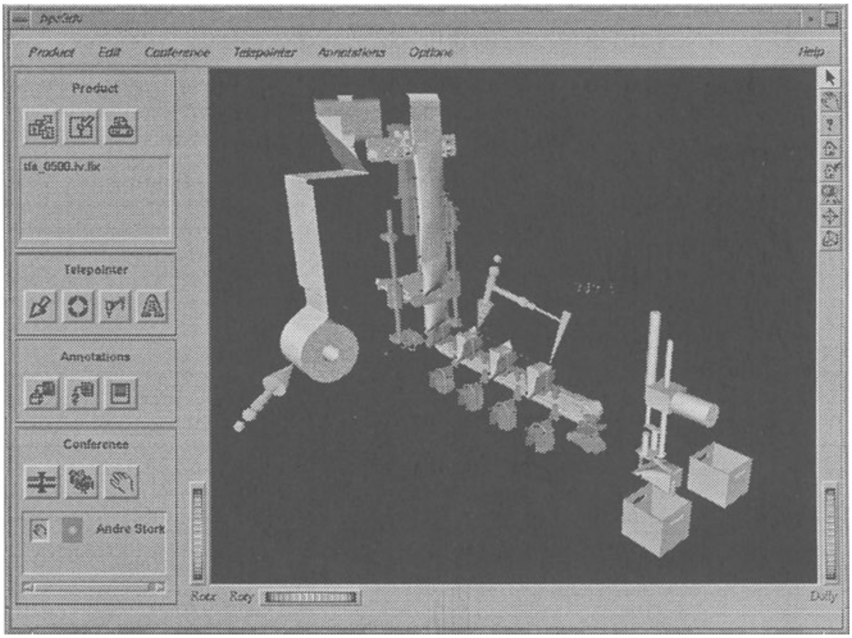

Figure 7 The Shared 3D Viewer

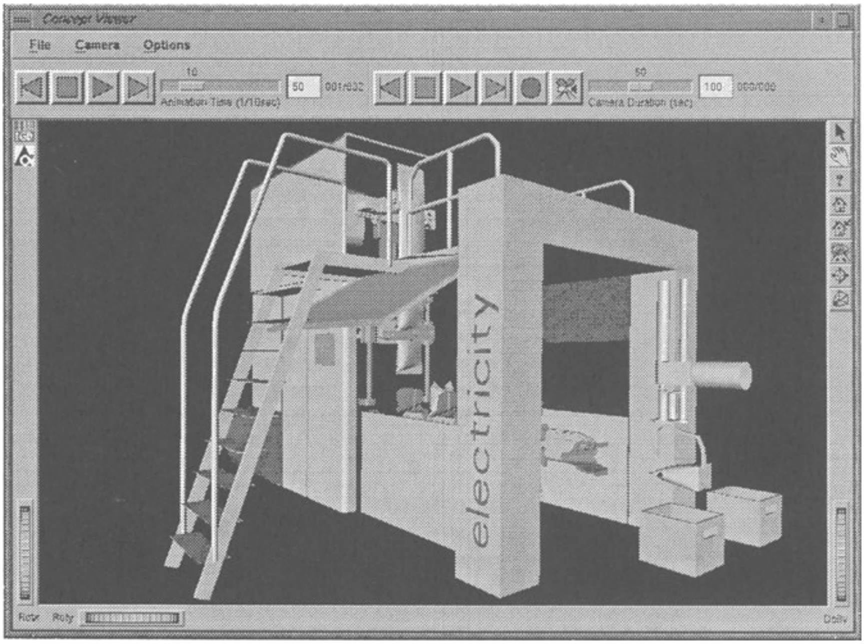

Figure 8 The Concept Viewer for visualizing basic behaviour

The first example, shown in figure 7, is used to facilitate the communication of distributed teams located at different sites. The Shared 3D Viewer (REF) can load all standard formats and distributes the resulting 3 dimensional CAD model throughout the network. As each instance of the viewer is running locally on the computer, the program can take use of all locally available performance. Different 3D pointers help the users during the discussion to identify the area of interest. As the application is a purely distributed one, the communication in-between partners is possible on a regular ISDN-connection.
The second example in figure 8 shows an application, which couples the geometry of the product with an animation sequence, showing the behaviour of the product. In addition, one can specify a camera motion to define a video path demonstrating the capabilities of this product.

6 INTRODUCTION OF VIRTUAL ENGINEERING

A five-phase approach is required to define and organise Virtual Engineering in enterprise itself and in the partnership of co-operative product development. If measures aimed at Virtual Engineering are to be successful, it is absolutely essential that the management of the enterprise issue a clear definition of objectives. It is important to ensure that the targets are realistic. The second phase entails a detailed analysis of the technical order processing. Weak-points are identified, processes are optimized according to the targets specified. The third phase builds on the concept and integration of VE into the process chain of product development. Next the system components that are necessary to realize the VE-concept are selected, implemented and customized. Additionally the staff has to be trained to the new technologies (figure 9).

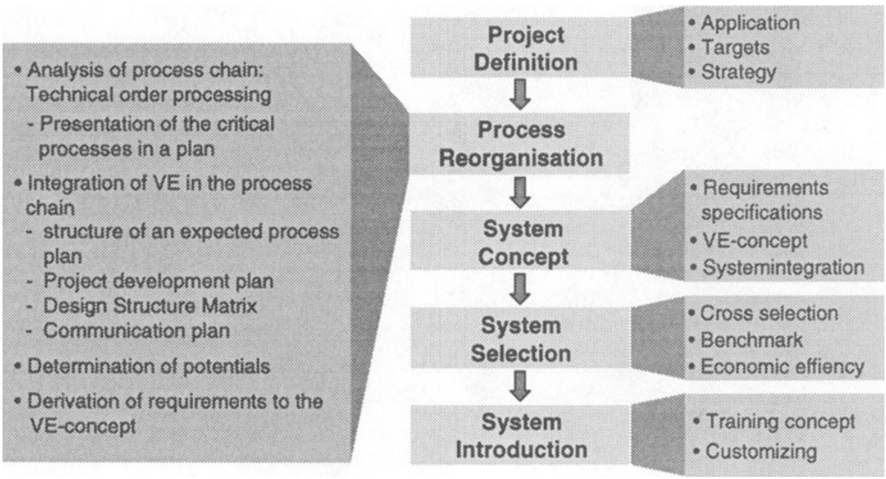

Figure 9 Introduction of Virtual Engineering

7 SUMMARY/ CONCLUSION

Innovative applications in the information and communication technology described above are increasingly permitting a logical distribution of value adding processes instead of localized concentration (Eversheim, 1997). Additionally they allow the simulation and visualization of complex interactions in early states of the cooperative product design process. The quality of product can be analyzed and optimized on basis of CAD-data (figure 10).

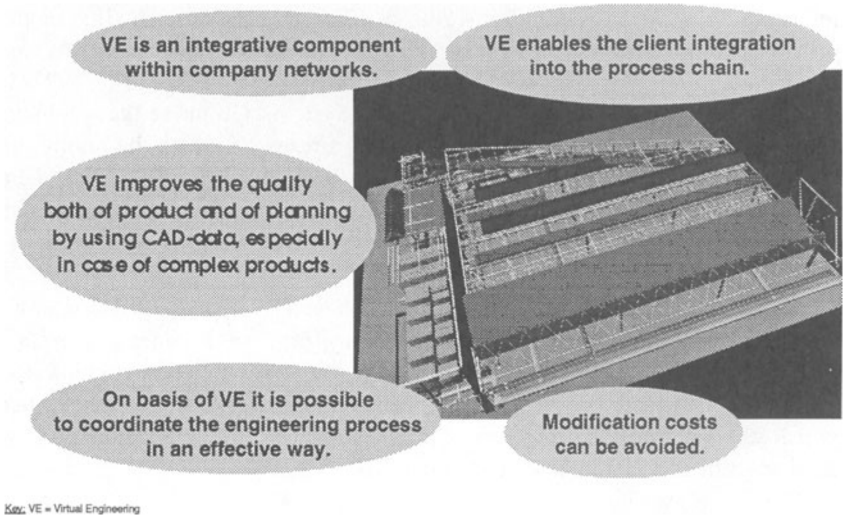

Figure 10 conclusion

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9 BIOGRAPHY

Dr.-Ing. U. Jasnoch received his university diploma in Computer Science from the Technical University of Darmstadt in 1989. In 1996 he received a Dr.-Ing. degree from the Technical University of Darmstadt. In 1989 he was a software engineer with Philips Kommunikations Industrie AG for one year. From 1990 to 1992, he was a researcher with the Interactive Graphics Systems Group at the Technical University of Darmstadt. Since 1992, he has been a researcher with the Fraunhofer Institute for Computer Graphics in the Industrial Applications Department. Between 1991 and 1993, Uwe Jasnoch chaired the "Consistency Management Working Group" in the CAD Framework Initiative.

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