Enabling IT for Mass Customization:
The IT architecture to support an Extended Enterprise offering mass customized products

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Abstract: The transformation from mass produced to mass customized goods is challenging. Such a radical change in the product nature forces a revision of the processes and supporting IT systems within an 'Extended Mass Customizing Enterprise'. Based on the processes for marketing, sales, design, production and distribution, an IT architecture in connection with all required information technology (IT) systems and their specifications will be presented. Finally a case study including the composition of standard business software tools to support the above mentioned processes of an 'Extended Mass Customizing Enterprise' will be presented.
1. Introduction

Mass Customization (Pine, 1993) becomes more and more popular. The main reason for that is: the consumer requires more and more individualised products satisfying their personal needs and wishes. Mass Customization is an approach for the manufacturers to fulfil these customer requests, to improve the competitiveness and to capture new market sectors by introducing new products. But, this re-orientation from mass produced to mass customized (individualised) products are challenging. Such a radical change in the product nature forces a revision of the product itself, the processes and the supporting information technology (IT) systems within an 'Extended Mass Customizing Enterprise'.

A crucial role for offering mass customized products is the support of the new processes (for marketing, sales, design, production and distribution) within an 'Extended Mass Customizing Enterprise' by appropriate (or new) IT systems. Otherwise, it would be very difficult for the customer on the one hand to configure and order easily an individual product and for the manufacturer on the other hand to produce a high quality individualised product with a similar production cost as of mass produced products and to deliver in a short time (cf. Pine, 1993).

2. The 'Extended Mass Customizing Enterprise'

The 'Extended Mass Customizing Enterprise' can be seen as an extended or in some cases as a virtual enterprise. The concept of extended enterprise is applied to an organisation, where a dominant enterprise 'extends' its boundaries to all or some suppliers whereas the virtual enterprise includes other types of organisations, namely a more democratic structure with a cooperation of equals (Camarinha-Matos, Afsarmanesh, Garita, Lima, 1997).

The extended enterprise collaborates with different actors (figure 1) like suppliers, partners, customers, etc. to streamline business processes - going beyond traditional boundaries and enhancing benefits for all. The integration ("extend" the boundaries of the existing enterprise) of different companies/actors in an extended (virtual) mass customizing enterprise is connected with the improvement of the performance of distributed organisations and markets. It focuses on the communication of information, co-ordination and optimisation of enterprise decisions and processes in order to achieve high levels of productivity flexibility and quality (cf. UCANet-Project, 2000).
The processes of the 'Extended Mass Customizing Enterprise' (figure 2) are very dynamic. The main stream process is the internal process at the manufacturer side. Beside this the interfaces to external partners, suppliers and subcontractors (supplier network) as well as the interfaces to the market/customers (distribution network) are part of the processes. This includes also the workflow management, handling of distributed manufacturing processes, the offer making/order process management and the selection of subcontractors and suppliers.

To manage the holistic processes appropriate and integrated IT systems are essential. The process builds the basis for the requirements regarding enabling IT for the process support of the extended enterprise offering mass customized products.
3. **Key Enabling IT for Extended Mass Customizing Enterprise**

Enabling IT is one of the main enablers for mass customization (cf. Piller, 1997). For this, a broad range of software tools (QAD, 2001) are required to offer customisable products at the market. These tools are able to reduce the increasing complexity of data, produced during the product life cycle of mass customised products. Thereby the progress of web technologies (internet and intranet) gives the ability to connect the extended or virtual enterprise with different actors, enabling rapid information flow over many regions or even globally. This helps to reduce communication cost and to increase the efficiency of the processes.

As mentioned in chapter 2, the IT systems have to be capable of handling the extended sales and supply chain (from acquiring customer requests to issuing the relevant design/production orders), the distributed manufacturing process and the design/engineering centres, and finally the network of suppliers (coordinating the production and the delivery of all the relevant components/parts/modules produced by suppliers).

Regarding mass customization the IT systems have to be capable of handling the increasing data flow by individual customer data and the customer specific product design and the increasing volume of product data by the bill of materials of each individual product by many “ad hoc generated” bill of materials. The systems have to have the capability to provide an online price calculation with real time delivery dates.

Therefore a fully integrated IT environment is necessary (figure 4).

![Figure 4: The process for mass customized products and the enabling IT system support](image)

As shown in figure 4 the key enabling IT systems are:

- Tools for Sales depending on the product type and the degree of individualisation, e.g. web-based product configuration system, sales portals, etc.
• Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) systems with quick adaptation, rapid design change capability and knowledge database

• Product Data Management System (PDM) for the handling of the increasing data flow (design drawings, bill of materials), etc.

• Enterprise resource planning system (ERP) with an interface to or including a Manufacturing Execution system (MES)

4. An IT architecture to support an Extended Enterprise offering mass customized shoes

In order to overcome all the difficulties during the transformation from mass production to mass customization of shoes, the EuroShoE project [Growth GRD1-2000-25761] (EuroShoE, 2003) has been set up. ‘EuroShoE - Development of the processes and implementation of management tools for the Extended User Oriented Shoe Enterprise’ is a three-year European Commission funded research ‘Growth’-project which was started in March 2001. The interdisciplinary consortium comprises 34 European organisations from shoe and software industry, as well as research institutes.

Figure 5 presents the EuroShoE IT-architecture, which presents the overview of the composition of standard business software tools and new/further software developments, which are necessary for the support of the processes within an extended enterprise offering mass customized shoes.

Figure 5: EuroShoE - IT architecture - Overview of the IT modules
The fully integrated IT architecture is divided into four main parts ("IT environments"):


2. **PDM system**

3. **CAD/CAM systems**

4. **ERP system, including - B2B-Portal- Manufacturing Execution System (MES)**

As maximization of design reusability and the formulation of a product platform (standardisation and modular design) are critical technical challenges for mass customization (Tseng, Jianxin, 2001), the product development/engineering is crucial for successfully implementing mass customization. This chapter focuses on the engineering tools within an 'Extended Enterprise' offering mass customized shoes. In this context the major implication regarding engineering is a fully integrated PDM-, ERP-, and CAD/CAM- solution (Bullinger, Wagner, Kürümlüoğlu, Bröcker, 2001).

**CAD/CAM systems**

The CAD systems have to offer the capability to handle quick adaptation needs and rapid design changes which arise due to the aim of adapting the shoe design to the specific requirements of each individual consumer. In order to blend and harmonise the design, engineering and biomechanical/anthropometrical constraints, data and decisions a knowledge database is additionally required. The integration (interface) of the CAD/CAM systems with a PDM system is very important for the design process.

**Product Configuration Systems (PCS)**

A visual product configuration system with logic capabilities to create, maintain, and use electronic product models that allow the complete definition of all possible product options and variation combinations, with a minimum of data entries and maintenance is essential for the companies offering unique products to satisfy specific customer needs. The PCS is used as an interface between the distribution and the other domains in the value added chain with the objective to support effectively and efficiently the sales processes and order processing. For the configuration of complex products, a configuration module of a PDM system is necessary. The rule-based configuration capabilities of PDM systems provide an important interface between visual sales-based product configurations and production-specific configurations expected by ERP systems.

**Product Data Management (PDM) Systems**

The product data management system characterises the holistic, structured and consistent administration of all data and processes that have to be generated, processed and transferred during the development of new or during the modification of existing products over their complete life cycle (Bullinger, Frielingsdorf, Roth, Wagner, a.o., 1999).

Regarding the characteristics of the ‘Extended Mass Customizing Enterprise’ the PDM system manages and provides data not only internally, but also towards external actors...
(suppliers, partners, etc.) involved in the product development process via a PDM web portal (‘collaborative product development’). Therefore the PDM system represents the link between the CAD/CAM and the ERP systems.

**Enterprise Resource Planning (ERP)-Systems**

The ERP system supports the main stream process as an enterprise-wide information system solution and manages the information flow in the entire value chain from sales to distribution. The modules of ERP system, that are necessary for an Extended Mass Customizing Enterprise are: Customer Relationship Management (CRM), sales, purchasing and procurement, production planning and controlling, supply chain management, quality management, logistics and administrative modules (like accounting, human resources, etc.). The EPR system supports also the integration and coordination of the suppliers and sub-contractors. Within the manufacturing process, work scheduling and planning with a maximum of flexibility is required.

5. **Conclusion**

For companies, mass customization of products means a radical change in their way of thinking and working. Starting with the new process of an ‘Extended Mass Customizing Enterprise’, new methods and tools have to be specified and introduced. Hereby the support of these processes within an ‘Extended Mass Customizing Enterprise’ by appropriate (or new) IT systems is essential.

6. **References**


