Mitchell M. Tseng
Frank T. Piller
Editors

The Customer Centric Enterprise

Advances in Mass Customization and Personalization

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The Customer Centric Enterprise:
Advances in Mass Customization and Personalization

edited by Mitchell M. Tseng and Frank T. Piller

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Preface: All yours

„All yours – mass customization transforms manufacturing in the 21st century," wrote *The Economist* in a 2001 feature article. Enterprises in all branches of industry are being required to become more customer centric, yet, at the same time, increasing competitive pressure dictates that costs must also continue to decrease. Mass Customization and Personalization are strategies developed to address this challenge by producing goods and services meeting individual customer's needs with near mass production efficiency. However, while mass customization and personalization have already been discussed in the literature for almost two decades, reports on practical implementation of the principles of mass customization in businesses can been found only within the last years.

Also, academic research and development of the theoretical and managerial aspects of mass customization and personalization is increasing rapidly. While an internet search of the term mass customization got about 350 results in 1995, nowadays there are more than 75,000 hits. According to a recent literature research, there are more than 2700 articles in English language published about the topic since the term was coined in 1989, about 60% of them within in the last two years.

The 2001 World Congress on Mass Customization and Personalization wanted to distinguish the buzz from the facts and to provide the first international, multi-disciplinary and broad platform for exchange and sharing best practices and innovative ideas in the field. The congress, jointly organized by the Advanced Manufacturing Institute and the Department of Industrial Engineering and Engineering Management (IEEM) of the Hong Kong University of Science and Technology (HKUST) and the Department of General and Industrial Management of the Technsiche Univesität München (TUM), was held at the HKUST in October 2001. As Co-Chairs of the conference, we were very pleased by the enormous feedback on our call for papers and the participations of the conference. Scholars from various academic disciplines, corporate executives from all over the world and other interested audience discussed the many faces of mass customization and personalization intensively and with much personal involvement.

The objective of this book is to share the results from the conference with a larger audience. We selected 29 papers from the original conference proceedings of more than 70 papers [1]. Selection of the papers was based first of all on the rankings of the reviewers' evaluation. In addition, we tried to select papers discussing specific topics or papers that provide a perspective on the broad scope of contemporary mass customization research and applications. After the selections and based on the discussion in the conference, authors were invited to revise, extend and update their original conference contribution. The idea of the book is to give the reader an introduction into the field, to show the scope of mass

customization research, and to present recent research findings and the state of the art in selected perspectives of this subject. We hope that our selection may fit your personal interests.

Mitchell M. Tseng and Frank T. Piller

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[1] Tseng, M.M. and Piller, F.T. (Eds.): Proceedings of the 2001 World Congress on Mass Customization & Personalization, Hong Kong University of Science and Technology, Hong Kong 2001 (available on CD-ROM at ami.ust.hk/MC01/MCPC.htm).

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Further information about the World Congresses on Mass Customization and Personalization:

Hong Kong, 2001: http://ami.ust.hk/MC01
Munich, 2003: http://www.mcpc2003.com

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Abstracts and Introductions

The following abstracts and introductions are taken from the original contributions of the book. The full texts will be available in *July 2003* when the book is published officially.

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Part I: Heading Towards Customer Centric Enterprises

1 The Customer Centric Enterprise

An integrative overview on this book

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Enterprises in all branches of industry are becoming more customer centric. The increasing interest and effort of business practices heading towards mass customization and personalization is met by an intensified and ongoing study of these approaches in research and academia. Though the oxymoron 'mass customization' was coined in the mid 1980's, research has started to pick up pace only in recent years. The number of papers published on mass customization and personalization has increased threefold in the last decade. With this in mind, the intention of this book is not only to discuss the state of the art of methods and approaches of more customer centric manufacturing, but also to show the obstacles and challenges of mass customization, and to analyze its potentials and capabilities. To open the discussion, the first part of this book gives a brief introduction into mass customization and personalization as key strategies of customer centric enterprises. Tseng and Piller comment on their understanding of both terms and illustrate the levels of a mass customization system from a generic perspective. Chapter 1 also presents a framework of the flow of activities in an extended mass customization system and integrates mass customization in the larger framework of supply chain management.

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Part II: Mass Customization and Personalization

Key Strategies for Customer Centric Enterprises

Being customer centric includes a wide range of strategies, approaches and ideas. Agile manufacturing, focused factories, flexible specialization, lean manufacturing, customer relationship management, and mass customization are strategies that emerged from the literature in the last decades. Despite different backgrounds and focus, the major objective of these new concepts is to improve the ability of enterprises to react faster to changing customers' needs and to address the heterogeneity of demand more efficiently. This book's emphasis is placed on mass customization and personalization which can be seen as key strategies for making firms more customer centric. Thus, Part II provides an introduction into principles, concepts, demarcations, and business models for mass customization and personalization. The scope of the contributions in this part is relatively broad. The intention is to sharpen the reader's view on customization and personalization and to give an overview into the reach and scale of these concepts.

Part II starts with an introduction into the extent of mass customization principles in industry. In Chapter 2 *MacCarthy, Brabazon and Branham* contribute to our understanding of both the potential of mass customization and the constraints under which real mass customizers may operate. The authors show that there is not one mass customization strategy. They present five case studies from a range of sectors – bicycles, computer assembly, communications components, mobile phones and commercial vehicles – and analyze their approaches to customization as well as their modes of operations. The scope of being customer centric is also the topic of Chapter 3 by *Riemer and Totz* on the many faces of personalization and mass customization. Their focus in on the emergence of internet technology enabling cost-effective one-to-one relationships with customers and, thus, new ways of doing business. Personalization (individual (one-to-one) communication) and mass customization (efficient product individualization) are discussed and set in relation to each other. The authors conclude that customization has to be accompanied by personalization of communication and customer interaction. They integrate customization and personalization into the online marketing mix. By doing so, the chapter provides a thoughtful discussion of the economic motivation of personalization and mass customization based on the capability of individualization to increase switching costs for the customers – resulting in deeper and more profitable customer relationships.

Does mass customization and personalization pay? *Reichwald, Piller, Jäger and Zanner* (Chapter 4) evaluate this question from an economic perspective. They apply a general framework for the economic evaluation of mass customization on a special setting of decentralized, customer centric production units (so-called mini-plants) located in close proximity to a particular local market. The chapter examines whether such a decentralized scenario of value creation could provide a suitable framework for the efficient production of individualized goods. The authors discuss whether the additional costs and hurdles of mass customization in mini-plants could be counterbalanced by the advantages of such a decentralized setting (compared to both mass production and centralized mass customization). Advantages could arise from new cost saving potentials and a higher consumers' willingness to pay for a customized solution. However, at the bottom line there is no generic rule as to when mass customization does pay. Only by evaluating the influencing factors of a particular situation can an answer be provided. With this in mind, *Thoben* contributes in Chapter 5 to the understanding of the nature of mass customization by comparing its system design principles with (traditional) customer driven manufacturing. Especially in Europe there is a long tradition of designing and manufacturing customer specific products such as machinery, ships and cars. The author evaluates synergies, similarities as well as limitations and potentials of both mass customization and (traditional) customer driven manufacturing. Bringing the discussion back to life experiences and case studies, *Franke and Mertens* discuss in Chapter 6 the use of personalization approaches in industry and public administration. While the theoretical foundations of user modeling and personalization techniques have been discussed in literature for several years, their practical implementation has been neglected for a long time. The authors share their experiences from a couple of cases of computer-assisted information, consulting, decision support and offering systems. These systems use

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personalization technologies to individualize the dialogue between man and machine pragmatically by user modeling based on content based filtering as well as social filtering.

Part II concludes with a new perspective: individualization and personalization are characteristics of art, as *Gros* discusses in Chapter 7. As Chapter 1 of this book has already shown, using the creativity of consumers may lead not only to better fitting products but also demands a new way of performing – and evaluating – value creation in industry. *Gros* sharpens our view of being customer centric by approaching customization as art. Applied art was once an important field of industry. However, as a result of industrialization and mass production, the link between art and consumer goods has been broken for almost a century. Now it could be assumed that new mass customization technologies may favor a rebirth of the association between art and consumer goods, a relationship coined 'art customization' by the author.

2 Examination of Mass Customization Through Field Evidence

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Mass customization excites interest across both the research community and business and industry. However there are issues and question marks over what it means and how it may be realized. More evidence of practice is required to understand the implications of adopting a mass customization strategy. This chapter presents five case studies from a range of sectors – bicycles, computer assembly, communications components, mobile phones and commercial vehicles – and analyzes their approaches to customization as well as their modes of operations. The type of the customization practiced by these different businesses is identified in terms of dimensionality (fit/size), hardware functionality, software functionality, properties of the whole product, grade, quality level, aesthetics and style, personalization, literature and packaging. All five businesses offer more than one type of customization. The implications of customizing different product attributes are discussed. The operational modes observed in the case studies are analyzed with respect to a typology of five modes of mass customization presented elsewhere. The reasons why different operational modes occur in different environments are speculated on. The chapter contributes to understanding both the potential for mass customization and the constraints under which real mass customizers may operate.

3 The Many Faces of Personalization

An integrative economic overview of mass customization and personalization

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The emergence of internet technology results in manifold opportunities of cost-effective one-to-one relationships with customers. It is intended to provide customer oriented information and products etc. in an individualized one-to-one manner. This chapter will give a conceptual overview of the personalization concept and will discuss how mass customization (product personalization) can be useful accompanied by other personalization activities, e.g. personalization of communication and customer interaction. Therefore the concept of personalization is integrated into the online marketing mix. The marketing mix discussion leads to a personalization perform-

ance system which shows the potential objects of web personalization activities from a customer's point of view giving a guideline for planning personalization activities. The model consists of the three main layers product & services, website and communication. This chapter will also provide a definition of concepts and an economic motivation of personalization and mass customization. Doing so, we want to integrate the marketing view of personalization and mass customization with the visualization of the personalization performance system.

4 Economic Evaluation of Mini-Plants for Mass Customization

A decentralized setting of customer-centric production units

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In this chapter we will present a new setting of mass customization value creation. Main elements of our approach are scaleable, geographically distributed and networked facilities – so-called mini-plants – each of them covering the majority of all value chain activities and located in close proximity to a particular local market. In addition, customization will be not only limited to physical goods, but extended to customized product-service bundles. The objective of this chapter is to examine whether such a decentralized scenario of value creation could provide a suitable framework for the efficient production of individualized goods. Our evaluation criteria are economical ones, i.e. the financial effects arising from such a setting. We will discuss whether the additional costs and hurdles of mass customization in mini-plants can be counterbalanced by the advantages of such a decentralized fulfillment situation (compared to both mass production and to centralized mass customization). Advantages could arise from both (1) new cost saving potentials as a result of a decentralized mass customization system and (2) a higher consumers' willingness to pay for a customized solution coming out of such a mini-plant.

5 Customer Driven Manufacturing Versus Mass Customization

Comparing system design principles for mass customization and (traditional) customer driven manufacturing

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For the last years the concept of mass customization has gained broad attention within various branches of industry. Mass customization has been identified as a competitive strategy by an increasing number of companies. Accordingly theoretical, technical as well as managerial aspects have been studied aiming at a better understanding of this new paradigm. However, especially in Europe there is a long tradition of designing and manufacturing customer specific products such as machinery, ships and even cars. For this chapter we have analyzed various industrial cases, consultancy projects as well as research work in the broader field of customer driven manufacturing. We will identify a number of design principles for the appropriate design of customer driven manufacturing systems. Doing so, we will discuss concepts and principles for the design of manufacturing systems delivering a wide range of products and services that meet specific

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needs of individual customers. Synergies, similarities as well as limitations and potentials of both mass customization and (traditional) customer driven manufacturing will be evaluated.

6 User Modeling and Personalization

Experiences in German industry and public administration

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Whereas the theoretical foundations of user modeling and personalization techniques have been the subject matter of many works for several years, their practical implementation in IS has been neglected for a long time. In order to change this, we developed a couple of computer-assisted information, consulting, decision support and offering systems in our research institute in cooperation with German firms and public administration. A guideline in all of our works is to pragmatically individualize the dialogue between man and machine by user modeling. The operational area of the experiments that will be outlined below ranges from personalized management information systems (MIS) to training and advising systems. One particular experiment will be considered in some detail. This is an online tourism and spare time advising system; it stores information about the user's cultural and leisure interests and generates individualized city tours or activity programs for longer stays. In order to do so, it uses content based as well as social filtering.

7 Art Customization

Individualization and personalization are characteristics of art

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It appears that people have almost forgotten that applied art once was an important part of the industry. In 1907, it was still possible for the Viennese architect Adolf Loos to assert that "without ornamentation we would only have to work four hours a day." This sounds plausible if, for example, we consider the percentage of artistic output involved in building a cathedral or building the first, delicately chiseled brass telescopes. Today, the link between art and consumer goods has been broken as a result of the industrialization of processes and products. Applied art has been subsequently ousted from architecture and design. However, we will discuss in this chapter whether the new technologies and processes of mass customization could renew the association between art and consumer goods. In view of the ever-growing possibilities offered by computer-controlled tools and the general trend towards individualization and personalization, a renaissance in applied arts could become much likely a feasibility. Applied arts could embody the highest degree of expressing individualism and personality. This movement is supported by the capabilities of modern technology: In our digital age, the applications for art have no longer to be found only in the realms of handicrafts (or in industrial processes) but could derive out of the conditions of a mass customization system – resulting in, so to speak, art customization.

Part III: Customer Centric Design and Development

Developing product families for customization and efficient manufacturing

Mass Customization aims at satisfying individual customers' needs with near to mass production efficiency. The implications of this new paradigm have positive as well as negative impacts for customers and manufacturers. On the one hand customers benefit from the availability of wide product variety in the market place, on the other hand they can be confronted with frustrating experience in selecting the right product that would exactly fit their expectations among a multitude of alternatives available. Similarly, manufacturers face the trade off between attracting more customers by providing them with large product variety and the need to manage this variety in design and fulfillment in such a way that operational aims like low cost, short lead times and high quality are met. The product design process (setting the solution space) plays a major role when planning and implementing mass customization. Providing value for customers by highly differentiated products without increasing the prices beyond customers' affordability is influenced heavily at the design level.

Thus, Part III of this book addresses the design issues of being customer centric. Managing the variety in the design domain is a challenging problem for manufacturers. The use of product families and modularization techniques are important means of dealing with this variety issue. Designing a family of products using a common platform approach instead of designing single products has gained momentum in various industries. Product families and common product platforms should help mass customizing companies to ensure economies of scale (on the level of modular components and platforms) while serving all customers differently (on the product level). In Chapter 8 *Du, Jiao and Tseng* present how an Architecture of Product Families (APF) contributes to generating families of products efficiently. APF is a logical organization of the product family covering the whole value chain from both a sales and an engineering perspective. Customer requirements in the functional domain are mapped with the variety parameters of a generic data structure for such a product family. Instantiation of the generic data structure determines the product structure and bills of materials, specific to customer specification.

Siddique and Rosen extend this discussion in Chapter 9 and present an approach to identify common platform architectures for a set of existing similar products. This is a major challenge faced by companies becoming more customer centric as it requires the development of product and process models and tools to facilitate configuration reasoning. The authors present an approach called 'Common Platform Identification (CPI)' focusing on the configuration aspect. Given different platforms for similar products, CPI first identifies the common modules. These modules are then re-modularized to enhance commonality further by breaking the modules that are not fitting to a common platform.

The topic of product design for modularity is also addressed in Chapter 10. *Cox, Roach and Teare* discuss how to increase productivity in the product development process by using reconfigurable models and product templates. In the last three decades, significant investments have been made in process technologies to increase productivity and efficiency in product development. But often the return on investment in these technologies has not yielded the gains in productivity that were expected, as new process tools were integrated into old product development processes. The authors argue that investments in new customer centric manufacturing tools and technology will be fruitful only when the product development process is made reconfigurable correspondingly. The authors show that the keys to increasing productivity are reconfigurable artifacts and product templates. By doing so, they provide important input to set up product development processes in mass customization systems which are characterized by the need for fast and efficient new product development processes.

Case-Based Reasoning and TRIZ are significant methodologies that, although not originally developed in a mass customization setting, can improve the design and set- up of customization systems. Estimating the cost of customization precisely, without exactly knowing all the manufacturing parameters and

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conditions, is an important means of providing the right quotations to customers during the order process. The ability to generate a quick and accurate quotation brings a significant advantage to mass-customized production companies. Unlike existing parametric cost estimation techniques that compute an estimate based on a mathematical relationship between product specification and cost, the approach presented by *Wongvasu, Kamarthi and Zeid* in Chapter 11 uses case-based reasoning to model the relationship between product configuration, resources requirement, and costs. Their approach can be further extended to estimate cycle times.

The TRIZ methodology has been proposed for solving the contradiction or trade-offs in different areas. TRIZ is a tactic for inventive problem solving. Its basic philosophy is to challenge the contradictions accepted as fundamentals. As the previous chapters of this book have shown, mass customization is characterized by trade-offs and the need to counterbalance these contradictions. *Mann and Domb* discuss in Chapter 12 the application of TRIZ in the area of mass customization based on four paradigm shifts. The authors analyze how systematic innovation methods are beginning to be used to successfully overcome rather than accept the trade-offs and compromises often held to be inherent. Understanding the trade-offs and contradictions of mass customization provides an important contribution to designing an appropriate "solution space" for a customer centric enterprise.

8 Product Families for Mass Customization

Understanding the architecture

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The rationale of developing product families with respect to satisfying diverse customer needs with reasonable costs, *i.e.*, mass customization, has been well recognized in both industry and academia. Earlier research often highlights isolated and successful empirical studies with limited attempt to explore the theoretical foundations surrounding this economically important class of engineering design problem. In this chapter we investigate the fundamental issues underlying product family development. The concept of Architecture of Product Family (APF) is introduced as a conceptual structure and overall logical organization of generating a family of products. APF constructs – including common bases, differentiation enablers, and configuration mechanisms – are discussed from both a sales and an engineering perspective. Further, variety generation methods are evaluated in regard to producing custom products based on the modular product architecture and configure-to-order product development. To support APF-based product family design, a Generic Product Structure (GPS) is proposed as the platform for tailoring products to individual customer needs and generating product variants. At the end of the chapter, we present a case study of an industrial example to illustrate the feasibility and potential of our proposed framework.

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9 Common Platform Architecture

Identification for a set of similar products

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Designing a family of products using a common platform approach instead of designing single products has gained momentum in various industries. One of the challenges faced by companies include identifying common modular platform configuration for a set of existing similar products, which requires development of product and process models and tools to facilitate configuration reasoning. The purpose of this chapter is to present a configuration reasoning framework that can be applied to identify common platform architectures. To accomplish this objective, first representations are developed for product architecture, then mathematical tools are developed to identify common platform from these representations along with a re-modularization scheme to investigate alternative architectures. Product architectures are discrete, as such graph and set representations are used to model product architectures. Discrete mathematical tools such as isomorphism are then adopted and applied to identify common platform architecture. The application of this configuration reasoning framework is illustrated using identifying common platform architecture for a set of automotive underbody front structures.

10 Reconfigurable Models and Product Templates

Means of increasing productivity in the product development process

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Over the past 25 years significant investments have been made in process technologies in an effort to increase productivity and efficiency in product development. However, the return on investment in these process technologies has not yielded the gains in productivity that would be expected. This chapter asserts that this is due to the injection of new process technologies and tools into old product development processes. Globalization and mass customization are also demanding higher levels of productivity. The solution to achieving effective returns in this area of product development lies in designing and implementing strategies that integrate and optimize the new process tools and technologies. Two primary product development strategies are emerging that integrate and optimize the new process tools; first, reconfiguration of product knowledge, artifacts and data, and second, the product continuum. The gathered data supports two conclusions. One is that product design processes that take advantage of reconfigurable models enjoy significant savings in time and cost in the model creation segment of the design process. The instantiation time for the reconfigurable models averages 3% of the time to create conventional models. As the size and/or complexity of the product increases, the potential benefit of reconfigurable models also increases. Another observation is that the reconfigurable template is an effective tool for organizing and administering design information in the process. The extra time spent setting up the reconfigurable models in the first design cycle is easily repaid through faster future design cycles, easier design information maintenance, and effective reconfiguration of

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previous work. Productivity as measured by reduced cycle times and increased throughput must be designed and built into the process. Our experience is showing that the keys are reconfigurable artifacts and product templates.

11 Case-Based Reasoning

Rapid cost estimation of mass-customized products

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The ability to generate a quick and accurate quotation brings a significant advantage to mass-customized production companies. Cost estimation is essentially a process that attempts to predict the final cost of a product, even though not all of the manufacturing parameters and conditions are known when the cost estimation is prepared. This chapter presents a case-based reasoning methodology for rapid and accurate estimation of cost of mass-customized products. Unlike existing parametric cost estimation techniques that compute an estimate based on a mathematical relationship between product specification and cost, this approach uses case-based reasoning to model the relationship between product configuration, resources requirement, and costs. Empirical results show that this approach produces reasonably accurate quotes. Thus, we contend that case-based reasoning approach hold a good promise for providing rapid and effective response to customers' request for quotation.

12 Using TRIZ to Overcome Mass Customization Contradictions

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The mass customization concept carries with it inherent contradictions between versatility and user benefit versus productivity or cost. Traditional trade-off and compromise based business approaches offer little to help overcome these contradictions. Thus, while many organizations are beginning to recognize the need for mass customization, few actually know how to tackle the issues involved in turning the concept into profit-making reality. The chapter discusses how systematic innovation methods are beginning to be used to successfully to overcome rather than accept the trade-offs and compromises often held to be inherent. Case study examples include design of mass customized bicycle seats, shoe products, novel room lighting solutions and home-customizable food products. The chapter ends with a discussion of these and other disruptive contradiction-breaking technology solutions in general.

The Customer Centric Enterprise: Advantages in Mass Customization & Personalization, edited by M.M. Tseng and F.T. Piller, Springer: New York/Berlin 2003.

Part IV: Interfacing and Integrating the Customer

Getting customers involved and optimally informed

The essence of customization is to provide only and exactly what each customer wants at the right time. The process necessary to reach this objective is the configuration process. Configuration means to transfer customers' wishes into concrete product specifications. While the basic product families, common product platforms and the corresponding manufacturing systems are set up when building a mass customization system, configuration activities take place with every single customer's order. For each order, the individual wishes and needs of a client have to be transformed into a unique product specification. The additional costs arising from the customization process consist largely of information costs in the sales. They are accounted for by the investigation and specification of the customers' wishes, the configuration of corresponding individual products, and the transfer of the specifications to manufacturing. All theses activities are characterized by a high information intensity compared to traditional mass production. An important characteristic of successful customer centric companies is the use of dedicated information systems to capture these additional costs. Called configurator, choice board, design system, tool-kit, or co-design-platform, these systems are responsible for guiding the user through the configuration process. Different variations are represented, visualized, assessed and priced by these systems, enabling the customer to interact closely with the firm's capabilities. While configuration systems theoretically do not have be based on software, all known mass customizers are using a system that is, at least to some extent, IT based. Configuration systems can also include physical measurement tools like 3D-scanners or visualization tools like 3D screens.

Part IV comprises of the discussion of configuration methodologies and modes for customer interaction. The development and implementation of appropriate systems for customer interaction is an important success factor of mass customization – and a field with many open questions (see also Chapter 30 of this book). The papers in this part should help to answer some of these questions. In Chapter 13 *Khalid and Helander* provide an introduction into web-based do-it-yourself product design (DIYD), as installed on many mass customization web sites. DIYD is defined as the selection and configuration of products by customers on their own. However, information about customer needs is usually incomplete, making it difficult to develop a configuration system both in terms of the set of options presented there and the corresponding user interface. Often, customer needs have to be estimated from population preferences or global market diversities. Of particular interest in this context is an investigation into appropriate procedures for customer design conceptualized in different cultures. The objective is to improve the usability of configuration web sites by addressing these differences. How consumers behave in such an environment is discussed by *Kurniawan, Tseng and So* in Chapter 14. Choosing, matching, and swapping components and configuration options and assembling them together to a specific product instead of choosing a ready-made product from a shelf is a totally new way of acquiring products for many consumers. Thus, the authors hypothesize that this may change known patterns of consumer behavior greatly. The authors present a new approach to understanding consumer behavior using the living system theory. While (traditional) marketing models rooted in psychological research assume that information (during the choice process) is evaluated by customers using symbolic processing, the living system theory explains customer behavior as a collection of components. Thus, a new way is offered in this chapter to better understand the essence of being customer centric: the customer.

Bee and Khalid extend this discussion with an empirical study evaluating three DIYD web sites in Chapter 15. Using factor analysis, three generic factors are extracted as important features from a customer's perspective, namely holistic design, navigability, and timeliness. Users seem to prefer a top-down hierarchical approach when designing the sample products (bicycles, watches, and dresses). The study also evaluated success factors for the corresponding design of the configuration system: design procedures, aesthetic preferences, information display, and design pleasure. The design and development of configuration systems corresponding to the needs of (potential) customers is also the topic of Chapter 16 by *Porcar, Such, Alcantara, Garcia and Page*. However, the authors follow quite a different approach and show how consumer expectations can be captured by the Kansei Engineering methodology. The

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chapter demonstrates how Kansei Engineering can be used to guide (inexperienced) customers in order to quickly find the desired design according to their preferences. This approach may also help manufacturers in cutting down a wide variety of options in manufacturing among which a large percentage does often meet not the preferences of the target group. Focusing production variability on features affecting most users' purchasing decisions may reduce the amount of design options offered, and may thus result in an important contribution to controlling costs and reaching near mass production efficiency in manufacturing.

Hvam and Malis extend the discussion on how to develop and design efficient and effective configuration systems. In Chapter 17 the authors present a documentation tool for configuration processes to foster knowledge based product configuration. Mass customization and similar approaches to create more customer centric product architectures led to an enormous extent of variety and complexity. This calls for an effective documentation system in order to structure this knowledge. Standard configuration systems do not support this kind of documentation. The authors sketch a rather simple application that serves as a knowledge based documentation tool for configuration projects. Their objective is to document complex product models in a way which considers both the development and the maintenance of the products. Part IV concludes with an important plea by *Svensson and Jensen* that the customer should always be at the final frontier of mass customization (Chapter 18). The authors show that despite all technological advances and approaches – such as the ones presented in the previous chapters – the central limiting factor in the expansion of mass customization will be the customer. Often, mass customization has mainly been turned towards product and processes. The authors argue that customers have to come fist. This is an important point that should never be forgotten when designing a customer centric enterprise.

13 Web-Based Do-It-Yourself Product Design

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Mass customization aims at providing cost-effective products and services to meet individual customer's needs. An implicit assumption of mass customization is that organizations must recognize customers as individuals and understand their needs. A central concept in this regard is the Do-It-Yourself Design (DIYD) approach that is contemplated in this chapter. DIYD is defined as the selection and configuration of product/parts by customers on their own. However, information about customer needs is usually incomplete. To develop and design a catalogue of products/parts (building the base for configuration) and an corresponding user interface for the configurator system, customer needs may be based on estimates of population preferences or global market diversities. In addition, rather general information concerning good taste, new product needs, easy design procedures and rules concerning web usability have to be taken into account. This information may be mapped as functional requirements using a hierarchical approach. Of particular interest in this context is to investigate appropriate procedures for customer design conceptualized in different cultures. Thus, we will investigate in this chapter the top-town hierarchical approach typical for Western engineering in two separate studies. Malaysian and Hong Kong participants supported hierarchical design in a Web-based DIYD process of watches. Additionally, this chapter comments on the design of usable Web sites and human factors issues for DIYD research.

14 Modeling Consumer Behavior in the Customization Process

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The essence of being customer centric is to provide only and exactly what each customer wants at the right time. The process to reach this objective is the configuration process. During configuration a consumer can choose different components and assemble them together to a specific product. With this new way of acquiring products, it is predicted that consumer behavior will change as well. This chapter presents a new approach to understanding consumer behavior using the living system theory. The paper follows the living system theory to explain consumer behavior by specifying its components, relations, and organization. The (traditional) marketing models rooted in psychological research have made many assumptions about human behavior, for example, the human brain is assumed to be similar to the computer brain and the processing of information is assumed to be symbolic processing. Living system theory is seen as an alternative solution. It has the capability of explaining customer behavior as a collection of components and their organization. Thus, it may become possible to emulate the consumer buying process by explaining this process as a collection of components and their organization. We will discuss this approach for the configuration process of a mass customization system. A case study is presented in order to illustrate the concept.

15 Usability of Design by Customer Websites

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The Design by Customer (DBC) approach is aimed at enabling companies to be more sensitive to what the customer really wants. The concept implies that users design a product using options offered by the company in a configuration system, while the latter assembles the product. There are constraints in providing the configuration system online, such as the types of product to offer, attributes of product for customer to design, and so forth. Therefore, design of a catalogue (representing the customization options) and of a corresponding configuration system is critical so that customers can be supported effectively in the design process. More important, what is designed is what the customer gets in the final product. This chapter reports the results of an experimental study that evaluates three DBC Web sites on user preferences of Web site features and e-catalogue-cum-configuration system. Using factor analysis, three generic factors were extracted for the DBC Web site features, namely: holistic design, navigability, and timeliness, while for the configuration system itself, the factors extracted represent design procedure, aesthetic preferences, information display, and design pleasure. The results also showed that users preferred top-down hierarchical approach for designing bicycles, watches and dresses. The Spearman rank correlation performed on the ordinal preference data showed significant relationships between the hypothesized and measured ranks for these Web sites. On the basis of this study, we derived specifications for an online configuration system of future Web sites.

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16 Applications of Kansei Engineering to Personalization

Practical ways to include consumer expectations into personalization and customization concepts

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This chapter proposes two practical ways to include user preferences in a personalization system aimed at psychological perception and based on a Kansei system. In many mass customization systems the consumer as an inexperienced designer can get lost and will become frustrated about the huge amount of offered possibilities. We will discuss how Kansei engineering can be used to guide customers in order to quickly find the desired design according to their preferences. Secondly, the number of possible design options and combinations in a modular personalization system can be higher than stocking, logistic and manufacturing capabilities. Focusing production variability on features affecting most users' preferences and purchase decisions may reduce this amount of design options. We will use case studies form the office furniture and footwear industry to support these ideas.

17 Knowledge Based Product Configuration

A documentation tool for configuration projects

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How can complex product models be documented in formalised way that consider both development and maintenance? The need for an effective documentation tool has emerged in order to document the development of product models. The product models have become more and more complex and comprehensive. A lot of knowledge is put into these systems and many domain experts are involved. This calls for an effective documentation system in order to structure this knowledge in a way that fits to the systems. Standard configuration systems do not support this kind of documentation. The chapter deals with the development of a Lotus Notes application that serves as a knowledge based documentation tool for configuration projects. A prototype has been developed and tested empirically in an industrial case-company. It has proved to be a success.

18 The Customer at the Final Frontier of Mass Customization

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Mass customization is no longer new. A decade of industrial experience have shown how this business paradigm has been used – and abused. Some companies report on a successful implementation leading to a radically improved business while others have not managed to fully exploit the promised potential. At this point in the evolution of mass customization one may look back and examine these cases with the purpose to empirically determine the factors influencing a

successful application of mass customization. However, one may also look into the future and speculate how mass customization may be further exploited. With this in mind, we will discuss in this chapter which factors may limit the further expansion of mass customization. We will argue that the customer is the major limiting factor at the final frontier of mass customization. Until now mass customization has mainly focused on the product. In this chapter we show that there is a need for an increased focus on the fulfillment of customer needs. As a result manufacturers have to balance new trade-offs if the paradigm of mass customization becomes a commodity. This chapter's objective is to open a discussion within research communities working with mass customization. Thus, more questions are raised than answered.

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Part V: Customer Centric Manufacturing

Process design, production planning and control for achieving near mass production efficiency

The term mass customization represents an oxymoron, and at no stage of the mass customization value chain is this more true than in manufacturing. The contradiction within the claim of producing high variety products with mass production efficiency poses a great challenge for manufacturing in any enterprise. Manufacturing for mass customization introduces multiple dimensions, including a drastic increase in variety, multiple product types manufactured simultaneously in small batches, product mixes that change dynamically to accommodate the random arrival of orders and the wide spread of due dates, and throughput that is minimally affected by transient disruptions in manufacturing processes such as breakdown of individual workstations. Solving the trade-off between customer centric manufacturing on the one hand (meaning high variety and fast responsiveness) and low costs, stable capacity utilization and high quality on the other necessitates incorporating systematic methodologies for manufacturing planning, process design and quality assurance in an integrated manner. Main enablers of customer centric manufacturing are modern flexible manufacturing technologies. They focus on batch production environments using multipurpose programmable work cells, automated transport, improved material handling, operation and resource scheduling, and computerized control to enhance throughput. The development, implementation, operative planning and control of these systems were the kernel of research on mass customization in the last three decades. But despite this history of research in the field, there are still many unanswered questions and new methodologies needed, as the chapters of Part IV will demonstrate.

Urbani, Tosatti, Bosani and Pierpaoli open the field in Chapter 19. The authors elaborate on the internal and external implications of mass customization and propose system capabilities which focus on flexibility and reconfigurability as a possible solution. They discuss the relationship between the principles of a mass customization system and the evolution of corresponding manufacturing systems. Several mass customization oriented paradigms are compared with a hypothetic, desirable evolution in market organization, providing an analytical approach. *Tsigkas, de Jongh, Papantoniou and Loumos* consolidate this discussion and present an innovative approach in Chapter 20 called "Distributed Flow Design and Development". This method should integrate product and process development. The objective is to boost the capability to sense quickly changing customer value requirements followed by the capability to rapidly transform these requirements and expectations in a variety of new product platforms and services. Their solution is closely related to the principles of lean manufacturing. Lean manufacturing and mass customization can supplement each other. The authors also introduce a new performance indicator to measure how fast an enterprise turns customer demands into value-adding mass customized products. A steady increase in this factor will lead an enterprise towards continuous, customer centric invention.

While the first two chapters of Part V argue on the level of strategic production planning, *Lopitzsch and Wiendahl* address the important issue of planning and controlling a mass customization manufacturing system on the operative level. In Chapter 21 they present their approach of "Segmented Adaptive Production Control" which combines the advantages of a customer-oriented push system with the benefits of an efficiency orientated system of pull control. In doing so, their approach merges KANBAN and CONWIP control systems. The system makes it possible to control the manufacturing of parts manufactured in mass production as well as of customized parts being produced at the same work stations. Traditional control approaches relying on either push or pull principles are unable to face the trade-off between variety and efficiency introduced by mass customization.

The next three chapters address mass customization manufacturing from a broader perspective. In Chapter 22 Schenk and Seelmann-Eggebert comment on the complexity of implementing mass customization in an existing mass or serial production system. Pioneering examples of customer centric manufacturing often focus on newly founded enterprises. However, most firms will implement mass customization principles within an existing setting. Implementing mass customization is reflected in all parts of a company

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and consequently in the entire supply chain. As existing production and logistics systems have evolved individually, no standard solution can be offered for the implementation of mass customization into an existing production line. The authors name some of the resulting challenges. An important point is the training of the employees in manufacturing which must be able to respond promptly to changing demands, too. Modularization can be seen as a main enabler and principle of being customer centric efficiently. However, though many companies have gained experience with modularization, there is still significant confusion about managing the modularization effort. The cause-effect relationships related to modularization are complex and comprehensive. In Chapter 23 Hansen, Jensen and Mortensen discuss the impact of modularization in greater detail. Recognizing the need for further empirical research, the authors formulate a research framework with the purpose of uncovering the current state of modularization using the example of Danish industry. Finally, Mchunu, de Alwis and Efstathiou present a framework for selecting a best-fit mass customization strategy in manufacturing. The authors report about their findings in a large-scale empirical project and introduce a methodology for characterizing the mass customization capability of a manufacturing enterprise (Chapter 24). Their methodology emphasizes the collection and analysis of quantitative as well as qualitative data. A key component is the use of a field workbook to collect triangulated data. Together with three other tools presented in this chapter, it forms a framework that aids the selection of an optimal mass customization strategy.

19 Flexibility and Reconfigurability for Mass Customization

An analytical approach

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In the 21st century, companies are going to operate in a dynamic and challenging environment that requires new approaches to manufacturing. Mass customization is a general trend that is more and more widespread, being felt as the productive paradigm for the future. On the manufacturing point of view, much work must be done to develop adequate manufacturing systems meeting the new requirements, since traditional solutions (both transfer lines and flexible manufacturing systems) don't seem to be able to face the demands of mass customization. However, not only manufacturing area is involved in this evolution but also managerial and organizational aspects. For these reasons this chapter discusses the relation between the mass customization paradigm and the evolution of manufacturing systems. Several mass customization oriented paradigms are compared with a hypothetic, desirable evolution in market organization, providing an analytical approach to flexibility and reconfigurability as possible means of facing today's competitive demands.

20 Distributed Demand Flow Customization

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This chapter will present new collaborative tools and methodologies enabling the rapid development of new product platforms and their corresponding manufacturing processes. The intended development cycle times are months for automobiles and computers, weeks for consumer electronics products, and days for many others. The new battlefield of corporate competition is

the capability and speed to create and transform "new" knowledge into personalized products and services. Lean and flow enterprises have the best chances for winning this battle. The proposed tools provide the missing link for the development of products and processes for mass customization. To address this challenge an integrating approach in product and process development is presented. The objective is to boost the ability in sensing quickly changing customer value requirements and expectations followed by the capability to transform these requirements and expectations rapidly in a variety of new product platforms and services. Doing so we will introduce a new key factor to measure the speed of an enterprise to turn customer demand into value-adding mass customized products. A continuous increase in this factor will lead an enterprise towards continuous invention which is translated into the speed to systematically and continuously mass customize products and introducing new ones. We call this enterprise an entropy enterprise.

21 Segmented Adaptive Production Control

Enabling mass customization manufacturing

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In order to generate product variants not only by customized assembly of standard parts but by individual manufacturing processes, an innovative production control is necessary. In this chapter, the methodology of the Segmented Adaptive Production Control is presented to perform this task. The approach combines the two basic control principles push and pull. Using the mass-production character of the pull principle and merging it with the customer-oriented push principle, the basic approach of mass customization is applied to production control. The sophisticated system allows controlling the manufacturing of both, parts manufactured in mass production as well as customized parts, at the same work stations.

22 Challenges of Mass Customization Manufacturing

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While the basic idea of mass customization with all its different facets excites marketing directors and CEOs, mass customization is still not yet a world wide standard. The reason for this can be seen in the complexity of implementing mass customization in actual existing mass or serial production. Pioneering examples of mass customization often focus on newly founded enterprises or on exclusively set up production lines. However, existing products, production and logistics systems have evolved individually. Thus, no standard solution can be offered for implementing mass customization into an existing production line. Questions such as which product, which feature and how many features should or could be individualized, remain. Implementing mass customization is reflected in all parts of a company and consequently in the entire supply chain. Therefore the manufacturing site needs to be redesigned in order to face the new challenges. Transport times have to be reduced within and between production lines. Producing lot sizes of one implies a need for high flexibility of the machinery, therefore an increased investment which must be planned thoroughly. Workers must be able to respond promptly to specific demands, too, hence resulting in a stronger need for special education programs and tools.

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23 Modularization in Danish Industry

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There are many pre-requisitions to make a mass customization strategy efficient. Speaking about the product dimension modularization seems to be an essential factor. However, though many companies have gained experience there is still a significant confusion about managing the modularization effort. In general, the phenomenon of modularization is not well known. The cause-effect relationships related to modularization are complex and comprehensive. Though a number of research works has contributed to the study of the phenomenon of modularization it is far from clarified. Recognizing the need for further empirical research, we formulate a research framework with the purpose of uncovering the current state in Danish industry and to identify tentative managerial implications.

24 A Framework for Selecting a Best-Fit Mass Customization Strategy

The MC Data Acquisition Framework approach

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This chapter presents a methodology for characterizing a manufacturing enterprise's mass customization (MC) capability. The methodology is essentially a case study that emphasizes the collection and analysis of quantitative as well as qualitative data. A key component of the methodology is the use of a field workbook to collect triangulated data. The application of this tool to the case of a durable consumer goods manufacturer is critically reviewed. This analysis gives rise to three additional tools that are separate, but complementary to the original field workbook. One of these tools, the MC Data Acquisition Framework is described in detail. It is a dedicated data collection tool, which improves upon the effectiveness of the original field workbook. The other proposed tools, the MC Focused Site Tour and the MC Competency Profile are briefly outlined. These tools form a framework that aids the selection of an optimal mass customization strategy.

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Part VI: Applying Mass Customization to the Fashion Industry

Building a customer centric value chain for apparel and footwear customization

The apparel and the footwear industry are both industries that are forerunners in the application of mass customization. The reason behind this development can be seen in the fact that clothes and footwear offer the potential to address all three possible dimensions of customization: fit (shape, measurements, size), functionality and aesthetic design (taste, forms). Products that require the matching of different physical dimensions or functional requirements often engender a higher price premium than products that are customized just by the possibility of changing colors or design patterns. Clothes and footwear are products that must, first of all, exactly fit their user's measurements. Additionally, customer integration into the aesthetic design of a shoe or a piece of clothes and the adaptation of functional requirements (like the profile of a sole, height of a heel; features of a fabric) are further means of increasing the utility of a product.

Thus, customization in this industry offers a good opportunity to counterbalance additional cost in manufacturing by a higher consumers' willingness to pay. Customization is also favored by more and more suppliers due to the steadily growing pace of change in fashion cycles, high forecasting problems, and multi-channel distribution systems. However, the change has just begun in the fashion industry. Despite various approaches like fast response supply chain systems, the use of digital models in product design, or manufacturing robots substituting the traditionally high level of human labor, the apparel and footwear sector is still dominated by traditional mass (variant) production systems. Thus, making these industries more customer centric is both a great challenge and an immense opportunity. Part VI addresses these challenges and provides a good insight into the various activities needed to transform an industry from a mass production system into a customer centric enterprise.

In Chapter 25 *Bullinger, Wagner, Kürümlüoglu and Bröcker* present the enabling information technologies for process management using the example of the footwear industry. Here, the change from mass production to a made-to-order system forces a complete revision of the processes and IT-systems that support the various phases of the product life cycle. Based on the EuroShoe Project within the 5th Framework Program of the European Community (www.euro-shoe.net), they envision the idea of an Extended User Oriented Shoe Enterprise. (New) appropriate IT-systems have to be selected and implemented. The chapter describes the demands of a transition from mass production towards mass customization in this industry. But not only IT and process design have to change. Mass customization will be only successful if appropriate sales systems exist. For example, customized clothes and shoes cannot be sold exclusively on the internet. The necessity of taking the measurements of each customer demands a direct interaction between seller and buyer. This prerequisite is supported by the demand of many customers for experience shopping or for the opportunity to feel fabrics and materials before the purchase. Thus, mass customization in these industries often requires strong cooperation with retail. This is the theme dealt with in Chapter 26 by *Taylor, Harwood, Wyatt and Rouse*. They present a strategic model for implementing mass customization for clothes on a UK High Street. Although mass customization clothing services have been available in some stores for over 10 years, they have been limited to men's suits. In an exploratory empirical study, the authors identify four stores offering (industrial) made-to-measure clothing and contrast them with four independent (traditional) tailors. The study provides interesting insights into mass customization from a retailer's perspective and may give manufacturers some ideas how to better tune their operations towards the demands of retail.

A special technology that is discussed often in the context of mass customization of fashion items is the use of individualized avatars (virtual mirrors). *Gurzki, Hinderer and Rotter* show how personalization technologies can supplement mass customization in the fashion industry in Chapter 27. The chapter gives an overview of the requirements of business-to-consumer fashion retailing and the available technologies.

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It develops an approach for an online shopping platform with individualized avatars for animated fashion presentation and integrated natural language text-based customer consulting features. As discussed above in Chapter 1 of this book: personalization is a major enabler for mass customization – not only in the fashion industry.

The last two chapters of Part VI specifically address two important means of becoming more customer centric in the fashion industry.In Chapter 28 *Luximon, Goonetilleke and Tsui* demonstrate how to achieve better fit in the footwear industry. Footwear fitting is generally performed using the two variables of foot length and foot width (or girth), even though feet and shoes are three-dimensional objects. As a result, the matching between feet and footwear are quite variable and can be quite unacceptable even for the same brand of shoes. Footwear fitters speak of 'perfect fit' even though the term 'fit' appears to be nebulous. The authors propose a method of quantifying 'fit' based on 3D tools. The proposed footwear fit quantification can be used to predict potential discomfort and even fit-related comfort if the material properties of the shoe are known. The method can also be used to rank different footwear lasts for any given individual.

However, evaluating the perfect fit of a shoe is one thing, designing and manufacturing it according to customers' demands is another. The foot data has to be translated into a customer specific last and shoe design. Thus, in Chapter 29 *Sacco, Vigano and Paris* evaluate how virtual reality technologies and CAD/CAM enable made-to-measure shoe manufacturing in mass markets. The authors discuss the state of the art of appropriate technology available and provide a glimpse of the future based on a virtual shoe design environment. With this system, a designer draws or modifies the style lines which were created before in the CAD system directly onto a (virtual) shoe model. Designers can fly-through the environment and interact directly with the virtual shoe using immersive interface devices. Such a solution is the starting point for the efficient manufacturing of customer specific shoes in mass markets.

25 Towards the Extended User Oriented Shoe Enterprise

Enabling information technologies for process management of mass customization using the example of the footwear industry

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Transformation from mass produced goods to mass customized ones is challenging but in some branches inescapable. Such a radical change in nature of production forces a complete revision of the processes and IT-systems that support the various phases of the product life cycle. EU-ROShoE is the first project putting this change into practice for the European shoe industry. The definition and the modeling of the mechanisms for an Extended Mass Customizing Enterprise (marketing, sales, logistic, production, administration, etc.) play a central role to redefine the processes involved in the product life cycles (design, production, distribution, and dismissal). Here the transformation from manufacturing of mass produced shoes to production of customized (customer oriented) ones, requires a thorough revision of the processes. In connection to the new processes of the Extended User Oriented Shoe Enterprise, (new) appropriate IT-systems have to be selected and implemented. With this in mind, the chapter describes the demands of a transition from mass production towards mass customization.

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26 Implementing a Mass Customized Clothing Service

A strategy model for implementing a mass customized clothing service in a High Street store

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This chapter explores how a mass customized clothing service could successfully be implemented on the UK High St and suggests a strategy model. In the present highly competitive environment clothing retailers need to gain a competitive advantage. Superior customer service was identified as a more effective competitive strategy than price or merchandise, since it is difficult to achieve consistent quality customer service, those that achieve it are not easily copied by competitors. Mass customization is a means of offering superior customer service, customers are supplied with a garment to meet their needs and also enjoy the personal attention this facility requires. System manufactures such as Lectra Systèmes are already collaborating with retailers in Europe to provide garment customization as an in-store service. Although mass customization clothing services have been available in some High St stores in the UK for over 10 years, they have been limited to men's suits. Four High St retailers were identified as having offered the service, however, two of these retailers have ceased the service within the last four years. In contrast the four Independent tailors interviewed offering mass customized clothing are expanding and developing their service. Structured interviews were undertaken in a survey of eight UK retailers. The sample consisted of four High St retailers and four Independent tailors.

27 Individualized Avatars and Personalized Customer Consulting

A platform for fashion shopping

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Electronic Commerce is growing world-wide. The fashion industry, however, has only experienced minor benefits from this growth. Major problems are the lack of customer consulting and missing possibilities to try on fashion products in online shops with high three-dimensional display quality. This chapter gives an overview of the requirements of business-to-consumer online fashion retailing and the available technologies. It develops an approach for an online fashion shopping platform with individualized avatars for animated fashion presentation and integrated natural language text-based customer consulting features. These technologies are a major enabler for mass customization in the clothing industry.

The Customer Centric Enterprise: Advantages in Mass Customization & Personalization, edited by M.M. Tseng and F.T. Piller, Springer: New York/Berlin 2003.

28 Footwear Fit Categorization

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There is a growing trend to sell many types of consumer products through the web in order to maintain or enhance a company's competitiveness, and sometimes to establish a niche market. For products such as footwear however, manufacturers are facing quite a challenge to provide consumers with good fitting shoes. Footwear fitting is generally performed using the two variables of foot length and foot width (or girth), even though feet and shoes are three-dimensional objects. As a result, the matching between feet and footwear are quite variable and can be quite unacceptable even with the same brand of shoes. Footwear fitters speak of "perfect fit" and more commonly a "proper" or "correct" shoe fit even though the term "fit" appears to be nebulous. This chapter is an attempt to quantify and categorize footwear fit. Using digital manipulations, the foot shape was "adjusted" to the required heel height. The last and foot were then mapped to each other to determine the level of match and mismatch. The magnitude of the match or mismatch was color-coded and overlaid on the foot surface so that such color maps can be used to determine subjective preferences. The proposed footwear fit quantification can be used to predict potential discomfort and even fit-related comfort, if the material properties of the shoe are known. The method can also be used to rank different footwear lasts for any given individual.

29 Virtual Reality and CAD/CAM for Customized Shoe Manufacturing

How virtual reality and CAD/CAM enable custom shoe manufacturing in mass markets

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This chapter examines some issues involved in producing custom footwear on a mass-market basis. The starting position for custom shoes is the measurement of feet. Traditional methods can be replaced nowadays more and more by modern measuring technology based on 3D scanners. While discussing foot measurements, the chapter will also address common misconceptions about foot measuring, shoe sizes, better fitting footwear and comfort. However, getting exact feet measures is just the necessary, but not the commensurate condition for customized footwear. The feet data have to be translated into a customer specific last and shoe design. In this context, we will outline the advances in current CAD/CAM software to facilitate the production of custom footwear satisfying the needs of mass-market consumers economically. Nowadays, shoe design is mainly done by hand. However, when providing custom footwear this is too time consuming and too vulnerable to errors when designs are interpreted in manufacturing. To solve this problem, the VRSHOE system was developed. A designer draws (creates) or modifies in this virtual shoe design environment directly on a (virtual) shoe model the style lines that were created before in the CAD system. Designers can fly-through the environment and interact directly with the shoe model using immersive interface devices. The user interface, the environment and the results obtained in this project will be presented.

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Part VII: New Directions

Future challenges for building the customer centric enterprise

Despite all the pages filled before with research on how to make enterprises more customer centric, there are still many open questions. Thus, the last part of the book discusses the future of mass customization, customer integration, and personalization. *Piller and Tseng* will comment on fields for further research needed to develop new processes, tools and programs for integrating the customer into value creating activities, both on the technological and the operational process side. They envision a future in which mass customization becomes an integral part of business operations, co-existing side by side with mass production. To this end, six areas are identified which require special attention when implementing a mass customization system n practice. These are also fields where more research is needed most.

30 New Directions for Mass Customization

Setting an agenda for future research and practice in mass customization, personalization, and customer integration

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In the closing chapter of this book we would like to share with our readers our view about the future of the customer centric enterprise and the enabling strategies of mass customization, customer integration, and personalization. We will also comment on fields for further research necessary for the development of new processes, tools and programs for integrating the customer into value creating activities, both on the technological and the operational process side. We identify six areas where – from our perspective and within our field of knowledge – more research is needed most. These are also fields which we think require special attention when implementing a mass customization system: (1) Issues concerning the design of products and product architectures. (2) Consumer behavior with customer interaction tools. (3) Drivers of customer satisfaction and dissatisfaction with custom made products. (4) Impact of integrating a user and customer into value creation on knowledge management and information management. (5) Capability analysis and systems engineering for concurrency in value chains. (6) Measurement of value contribution in mass customization systems.

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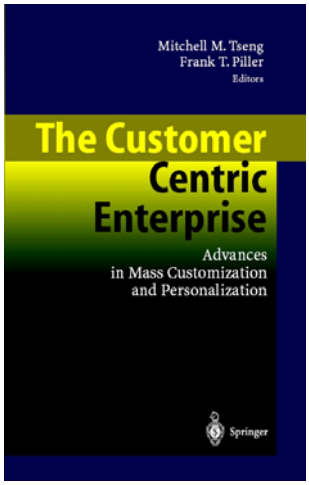

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Companies are being forced to react to the growing individualization of demand. At the same time, cost management remains of paramount importance due to the competitive pressure in global markets. Thus, making enterprises more customer centric efficiently is a top management priority in most industries. Mass customization and personalization are key strategies to meet this challenge. Companies like Procter&Gamble, Lego, Nike, Adidas, Land`s End, BMW, or Levi Strauss, among others, have started large-scale mass customization programs. This book provides insight into the different aspects of building a customer centric enterprise. Following an interdisciplinary approach, leading scientists and practitioners share their findings, concepts, and strategies from the perspective of design, production engineering, logistics, technology and innovation management, customer behavior, as well as marketing.

More Information at www.mass-customization.de/cce

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