Reference Models for Mass Customisation Production of High Fashionable Products: Application to the Shoe Manufacturing Domain

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Abstract. In order to face the competitors with low cost of human resources, one solution consists for industrial enterprises to evolve from mass production to mass customisation. In this kind of system, the product is customised for each customer in order to answer his requirements at the best . In this frame, several European shoe enterprises have decided to evolve towards mass customisation in order to offer customised shoes with an industrial way of working. In order to help them in this task and to derive research results, a European project has been set up: the Euroshoe project ("Development of the processes and implementation of management tools for the Extended User Oriented Shoe Enterprise" - *GRD1 – 2000 - 25761*). The objective of this paper is to present how the enterprise modelling techniques were used in the project in order to identify the existing running of shoe companies and to define reference models for the future running of these mass customisation manufacturing systems.

1 Introduction

If the 20th century was the one of mass production, the strong competition in a global market has modified the way companies will do business in the 21st century. In order to face the competitors with low cost of human resources, one solution consists for industrial enterprises to evolve from mass production to mass customisation [1]. The term took its root since the publication of the book *Mass Customisation* [2] and another book *Agile Product Development for Mass Customisation* [3]. In this kind of system, the product is customised for each customer in order to answer his requirements at the best. In comparison to classical One of a Kind Production system, mass customisation implies to have for each product a design phase combined with mass production. This leads to high-mix

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system with lean organisation which aims to minimize costs and lead time. The purpose is to have performances close to mass production ones with more adapted services.

In this frame, several European shoe enterprises have decided to evolve towards mass customisation in order to offer customised shoes with an industrial way of working. In order to help them in this task and to derive research results, a European project has been set up: the Euroshoe project ("Development of the processes and implementation of management tools for the Extended User Oriented Shoe Enterprise" - *GRD1 – 2000 - 25761*).

The objectives of this project, including thirty three partners, were to imagine, to specify, to develop and to implement techniques (machines, software, ….) and organisations required for a shoes mass customisation system, from the scan of the feet, the product configuration, the design of adapted last, sole, uppers, to the final assembling of the shoe and its distribution to the final customer using express mail. The total lead time targeted is two weeks maximum.

The objective of this paper is to present how the enterprise modelling techniques were used in the project in order to identify the existing running of shoe companies and to define reference models for the future running of these mass customisation manufacturing systems. The methods used were mainly IDEFØ and GRAI.

Another challenge of these reference models is to be generic enough to be reusable for other kinds of mass customisation systems as fashion clothes.

So, after a slight presentation of the Euroshoe project, the paper will present first how the six enterprise models were built with the selected enterprise modelling methods. Then, all these models were combined in order to build an equivalent AS IS model. The interest of this equivalent AS IS was to have a synthetic view of common existing practices in this domain.

Then, based on the equivalent AS IS models, a first diagnosis was elaborated and will be presented in the second part of the paper. This diagnosis highlighted the strong points and the points to improve in such systems. This diagnosis was derived and extended for each system in order to advice each company on points to improve in their current system.

In a third time, the paper will present the TO BE models, i.e. the models of the future system for a typical mass customisation system for shoe manufacturing.

2 The EUROSHOE Project

EUROShoe [4] is a research project aiming at a dramatic renovation of the concept of the shoe as a product and of its production, based on the transformation of the first from a mass produced good towards a mass customised one. This product evolution goes in parallel with a transformation of footwear companies into extended and agile enterprises capable of handling the complexity that such a change in the nature of the product implies and of mastering the new challenges deriving from a direct involvement of the consumer in the design and manufacturing process of the shoe he is going to buy. Such a radical change in the product nature forces a complete revision of the processes that support the various phases of the product life

cycle (design, production, sale and distribution, use, dismissal and recycling) in a systemic view that is developed within the EUROShoe project according to the model of the product – processes matrix leading to a research effort that encompasses the development, for each of them, of all the relevant critical technologies. This total and global rethinking of the footwear business needs large resources and the EUROShoE project is therefore an ambitious and large research initiative involving all the actors of the value added chain.

The approach is, on one side, looking at the *"shoe system"* and on the other side developing the necessary methodologies and technologies needed at every step of the value added chain.

The project originates from the statement that there is a trend that indicates a growing demand for a certain level of customisation in the products or services the consumers are buying. This trend is certainly similar to what exists for products like cars, garments or services of various kinds.

The challenge of the EURO ShoE project is precisely to manufacture customised / custom made shoes (so shoes that can guarantee a much higher level of individual satisfaction) at a price that is affordable for the great majority of the consumers.

Having a such research wide scope, several results are expected. The main project outputs can be summarised as follows:

- a *detailed survey* of the specific aspects of the demand for customised shoes,
- a *reference model* of the business and operational processes of the shoes companies,
- a *set software tools and procedures* to select, configure, integrate ERP/PDM/CAD/CAM,
- a *fully implemented ERP/PDM/CAD/CAM environment* for a testbed,
- a new generation of foot *feature capturing devices* and camera based foot *scanners*,
- a *knowledge based CAD/CAM software* for the design of customised shoes,
- a variety of *new design versatile and multi purpose shoe machines and systems*, and
- a *physical and virtual (web based) sale environment* for the selection of customised shoes.

The second output will be especially detailed in the following part of this paper.

3 The reference models: from AS IS towards TO BE models

The methodology set up to develop generic TO BE models is presented figure 1. In order to understand the running of shoe manufacturing companies in Europe, six different enterprises were modelled. These six companies were located in different countries, with different sizes (from 50 to 2000 employees), different cultures, different organisations (single or in supply chain). So, even if the GRAI Methodology [5] includes five kinds of models and views, according to the project

objectives, it was applied in order to model each company from only three points of view: functional, physical, and decisional.

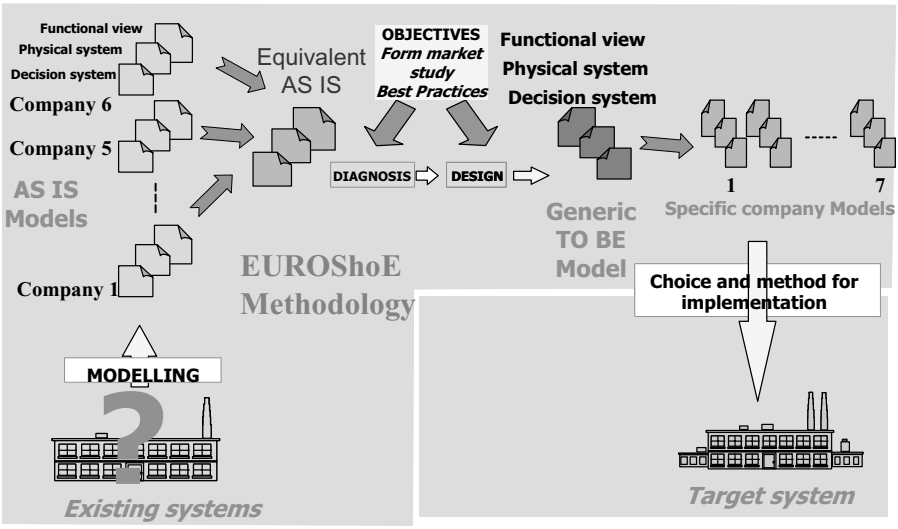

Fig. 1. The EUROShoE methodology to develop reference TOBE models

Based on the six models, an equivalent (generic) AS IS model was developed in order to synthesise the practices. Then, based on the diagnosis about the equivalent AS IS and on the objectives of shoe industry for mass customisation identified from the market study, a vision was defined and then Generic TO BE model was elaborated. Finally, the generic TO BE was instantiated for the six specific companies and one scholar case study.

3.1 Equivalent AS IS Model

The objective of equivalent AS IS model was to describe a synthesis of the mechanisms and operation logics which cover all the functions of the extended enterprises [6].

In fact, each of the six enterprise models was scrutinised in order to detect common ways of running and to create a consistent overview and detailed knowledge about shoes manufacturing.

So, the equivalent AS IS model was build from several points of view: the functional view, the physical system which adds value to the product and the decisional system which controls the physical system. This AS IS model covers the various functions of enterprise, from the merchandising to the distribution. However, it was mainly detailed for the design and the manufacturing functions because the mass customisation system required a very high integration between these two parts of the enterprise.

The equivalent AS IS models from functional and decisional points of view are presented figure 2 and figure 3.

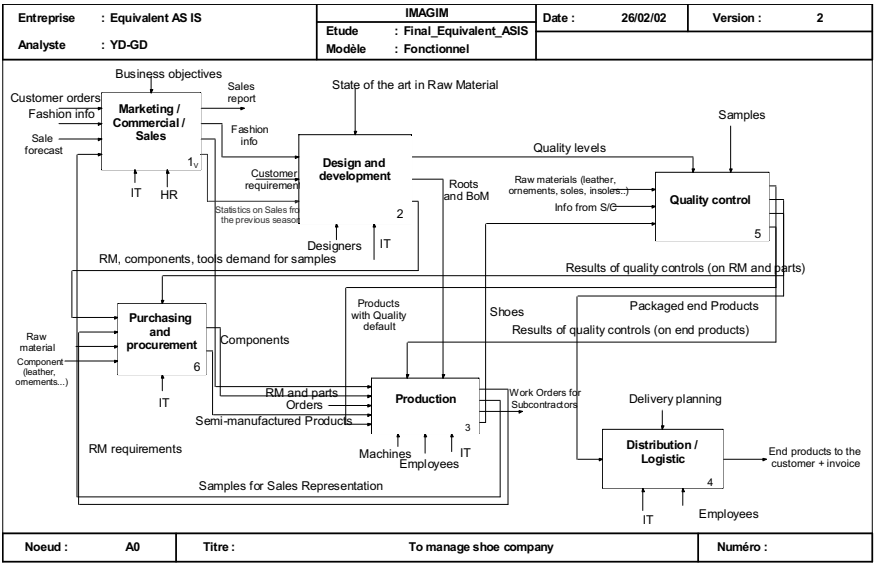

Fig. 2. Equivalent AS IS Model for the functional view at the global level (A0)

The functional view was performed using actigram formalisms [7]. Six main functions have been selected in order to limit the domain of study for the existing systems. The links between functions are shown as well as required resources (mechanisms) to perform the functions.

In order to limit the length of this paper, only this diagram is presented but each function was detailed. Moreover, the equivalent AS IS of physical system was also performed and detailed for each activity: to design shoes (to generate new ideas, selection or design of last, selection or design of sole, design or modifications of uppers, production and test of prototype and industrialisation), and to manufacture shoes (to manufacture uppers, to assemble, to finish and to deliver). Finally, the equivalent AS IS model was performed from a decisional point of view using GRAI Grid as shown figure 3 and GRAI nets. In this GRAI Grid, the functions are almost the same than for the functional view and the central functions are the decomposition of the production function: to manage products, to manage resources, to manage production planning. This equivalent GRAI Grid includes most of the points to improve in the shoe manufacturing companies:

- few long term decisions,
- a lot of decisions with a period of six months, corresponding to the period of a collection, which are not reconsidered during this collection (horizon=period),
- decisions with coordination problems (several objectives in conflicts…),

- no decision concerning the management of final customer satisfaction: the shoe companies have relationships with retailers but not with final customer which leads to a lack of knowledge about the customers' expectation and a lack of returns,
- few anticipation of quality problems at long term, and
- no decision on modification of a model at short term by Design and Development department.

So, most of the principles of mass customisation are not implemented in the current systems.

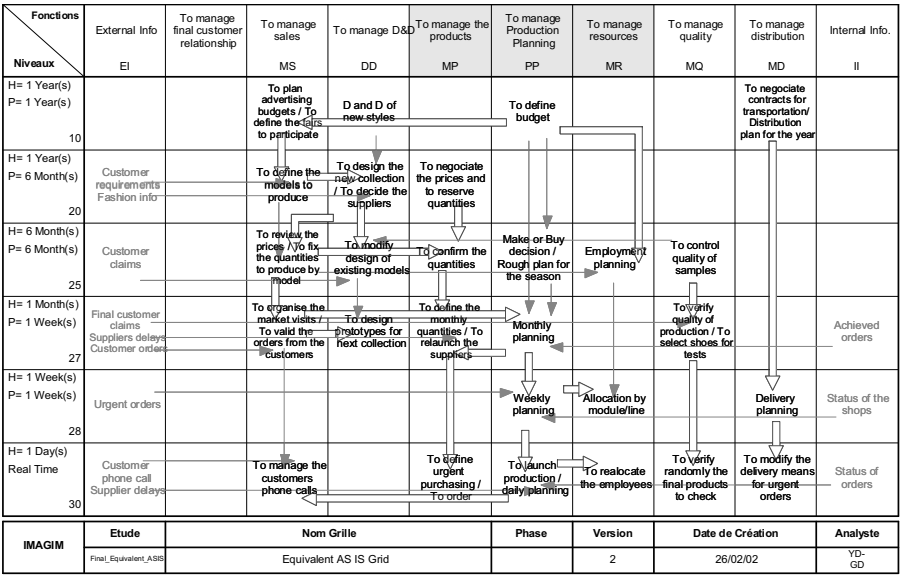

Fig. 3. Equivalent AS IS Model for the decisional system: equivalent GRAI Grid

3.2 The TO BE Models

The first base for these models was of course the experience gained during AS IS modelling, equivalent AS IS and diagnosis elaboration. The second base was the vision of experts [8] of shoe manufacturing, mainly consultants in charge of shoe manufacturing improvement.

This vision explained how this kind of system should operate, according to the new technologies available for shoe design and manufacturing and the expectation for each of the six companies for the future.

The generic TO BE model includes functional modelling as shown figure 4.

In comparison to the model of figure 2, it was decided to combine marketing function with CRM (Customer Relationship Management) because CRM aims to better know the customers and to improve their satisfaction.

The sale function is now independent because it involves more activities as the scan of the feet and the product configuration as well as customer data collection.

Purchasing and procurement include a quality control function which enables the final company (which performs the final assembling) to select the leather and materials. Quality control is also integrated to the production in order to have a quality deployment all along the production process. Of course, all these six activities are detailed.

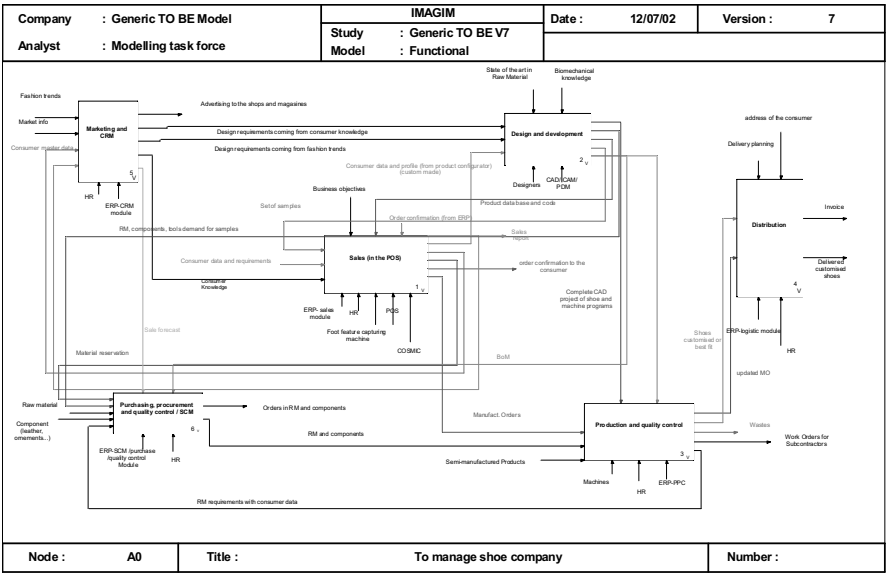

Fig. 4. The functional TO BE model at the global level (A0)

In a second time, process modelling was performed including sales, design, manufacturing and distribution activities. Each of these four activities was detailed at several levels in order to have a very deep and detailed view of each elementary activity in order to specify future machines and software functionalities to design, sale, configure and manufacture shoes.

This TO BE model also includes decisional modelling for the whole enterprise, including manufacturing (figure 5) and then design.

The functions of the GRAI Grid are adapted to the functional view of figure 4. The main change is to consider that the shoe production control is not aligned on a six month collection but that the collections are continuous. So, it is possible to have long term decisions as a business planning with a horizon of three years. The number of decision levels is limited to five: one strategic, two tactical and two operational. The management of resources is improved in order to forecast and adapt the required capacity to the various collections (at least, four a year).

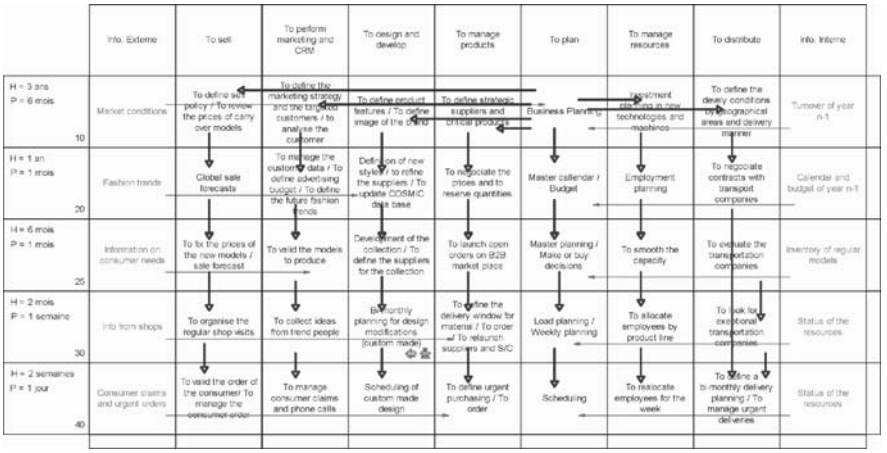

Fig. 5. Decisional global view for the TO BE Model: TO BE GRAI Grid

4 Conclusion

Enterprise modelling was fully used to understand the different mechanisms of shoe manufacturing in Europe. More than sixty models for the existing systems were obtained using GRAI Methodology and IDEF0. Then, thirteen equivalent AS IS models were elaborated to synthesise the current shoe mass production. So, based on the diagnosis of these models and the vision of experts, enterprise modelling was used to describe the future of shoe systems. Thirty five TO BE models (8 functional views, 20 process views, 2 GRAI Grids for the whole enterprise and for design activity control and 5 GRAI nets) were defined. These enterprise models were used to specify functionalities of machines and software (ERP and CAD) for shoe mass customisation system.

The following of this work was the instantiation of the TO BE model for the scholar shoe manufacturing system of Caslano (Italy). In the future, these TO BE models will be instantiated to the six companies and will be generalised for other mass productions of good and services.

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