Supporting product development in the textile industry through the use of a product lifecycle management approach: a preliminary set of guidelines

SUPPORTING PRODUCT DEVELOPMENT IN THE TEXTILE INDUSTRY THROUGH THE USE OF A PRODUCT LIFECYCLE MANAGEMENT APPROACH: A PRELIMANARY SET OF GUIDELINES

Enrico Vezzetti[a], Marco Alemanni[b], Javier Macheda[a]

[a]Dipartimento di Ingegneria Gestionale e della Produzione

Politecnico di Torino, Italy

enrico.vezzetti@polito.it

[b] Maneat s.r.l., Italy

marco.alemanni@maneat.it

Abstract

Product Lifecycle Management (PLM) is in some segments, such in the Aerospace and Defence (A&D) and Automotive fields, a well known business approach to support Product Development. However, while these markets recognize the power of PLM, others, such as Textile, which searches for more performing solutions to meet the new globalized market competitiveness, still need to take the first steps towards a better understanding of how a PLM strategy could support their businesses.

For this reason, this paper aims to provide a roadmap about where an how PLM could support the development of Textile products, in particular those ones that should be quickly innovated in order to answer to the volatile customers' demand (Fast Fashion scenario), adopting a user-centred approach. Starting from a rigorous formalisation of the textile New Product Introduction process (NPI), weaknesses and strengths have been then formalised via the involvement of NPI stakeholders catching and analysing their needs as users/actors (IDEF0). This set of requirements has been then correlated with the PLM features, through the use of Quality Function Deployment (QFD), in order to define a set of guidelines describing for each NPI process how PLM features could be linked and which benefits could be obtained with this link.

These guidelines could help Textile companies to have a clearer idea of the advantages that could be obtained through the adoption of the PLM approach. Hence, the proposed methodology is able to provide to the company with a quantification of the impact of the PLM features on its processes. Moreover, it could support Vendors to provide their solutions with more tailored features.

Keywords: Product Lifecycle Management, Textile, Fast Fashion, Quality Function Deployment

1.0 Introduction

Aerospace and Defence as well as Automotive companies are well aware of the fact that it is currently impossible to survive or acquire new market segments without a proper organizational strategy oriented towards product lifecycle [1,2]. Thus, together with an organizational approach, it is necessary to adopt the right methodologies and tools. PLM [3,4] is a suitable answer. The synergy between right methodologies, tools, and business organization is the only way to develop complex systems (aircrafts,

cars,…). In a "mass customization" scenario, the presence of highly complex products with several possible configurations and the need to maintain reduced cost can only be achieved through a product lifecycle-oriented approach.

Even though adopting a PLM strategy is a non-trivial choice [5,6], it is a key technology for simplifying the early entry of companies into the market, in terms of planning, organisation, management, measurement, and delivery of new products or services in a much faster, better, cheaper, and integrated way [7].

Efficient management of multiple products that satisfy the needs of multiple disciplines is an important issue that PLM is able to address in order to support product innovation by reducing all those processes that cause product data redundancy due to the different needs of each specific enterprise [8,9,10].

However, although PLM has reached a high level of maturity in the Aerospace and Defence field, as its advantages are already well known and structured guidelines and frameworks have been provided in this context [11,12], the situation looks much more fragile in other industrial fields, characterized by complex products.

While in the Aerospace and Automotive sectors companies deal with New Product Development (NPD), where the core business concept is that of 'developing' new products with a focus on the R&D and design phases, in the textile industry the NPD concept is replaced by New Product (collection) Introduction (NPI) [13]. This term is used to underline the fact that the key factors in this sector are time to market and quality of the garments. The main phases that generate the NPI process are: *planning, product design and development, material and colour development, sourcing, and quality and compliance assurance.* The abovementioned phases should be carried on by following a concurrent engineering approach. The co-existence of several simultaneous tasks is cumbersome, as the outcome of one action influences the results of another. Hence, the players should constantly be up-to-date about the ongoing activities they are involved in [14,15]. Like every other industry, the final good may be produced through in-house or outsourcing methodologies [16]. In both cases the main company is in charge of material procurement; its aim is to guarantee a high quality of the final product. In the 'outsourcing' case, the material is selected, purchased, shipped to production factories, and then the garment is brought back and sold.

Within this scenario, in the last few decades, certain companies such as Benetton, H&M, and Zara have revolutionized the sector by adopting the so-called 'fast fashion' philosophy, in which retailers prepare their production in a few weeks time only, instead of the standard six months [13]. The concept of fast fashion was born in Europe to meet teenagers' and young adults' desire to have trendy, short-cycle, and relatively inexpensive clothes, and to buy from small retail shops and boutiques [17].

While in the past the textile domain was characterized by small and medium companies with a different product lifecycle, able to guarantee higher net margin, at present the scenario is completely changed. Nowadays companies face shorter product lifecycles with reduced net margin that obliges them to control the core processes (portfolio management, project management, production planning, knowledge reuse, …) through the adoption of proper and tailored methodologies and tools for exploiting their best knowledge [18].

Companies in the textile industry are currently attempting to adopt the best practices implemented by the abovementioned brands in order to be able to reduce the lead time of their production. In other words, to shorten time to market (TTM). "*In the fast-paced world of textile retailing, nothing seems more important than TTM*" (Michael Weiss, CEO of Express). In the textile industry, companies are working on developing new products on the market at an increasing pace. Rapid changes in customers' preferences and fierce competition between rivals have encouraged suppliers to reduce their lead times for new and trendy products. The activities aimed to accomplish these tasks have become more and more complex due to globalization, as the number of possibilities to be chosen has increased, together with the need for more

specific materials and products. In short, as John Thorbeck, CEO of Supply Chain, said, 'Zara has proven that speed and flexibility matter more than pure price' [19].

To achieve this aim, Textile companies adopt approaches such as Agile [20] and Quick Response [21] to meet the continuously-changing customers' demands to reduce TTM to the shortest time period. However, those solutions such as Collaborative Demand Management and specific Enterprise Resource Planning (ERP) are 'stand-alone'. As a consequence, firms lack all the collaborative features which provide the right data to the right user at the right time. This is only achievable by embedding integrated solutions that, more than the vertical IT stand-alone tools, can provide collaborative features. These are necessary for supporting data sharing along the entire product lifecycle and consequently also for maintaining the whole company process under control. This could be gained through the adoption of a PLM strategy, but it seems [18] that the actual PLM solutions present inappropriate elements that do not boost textile companies to approach this strategy. As a consequence, a rigorous scientific methodology is due, able to capture the latent needs of Textile New Product Introduction and to further map them with the main PLM processes/features.

The paper is structured as follows. Section 1.1 offers a review of technical literature on textile domain innovation tools and methodologies. Section 2.0 provides a description of the scientific methodology employed (Section 2.1) to analyse the NPI latent needs, together with details of the PLM features (Section 2.2). Results are discussed in Section 3.0 by providing a preliminary set of guidelines. Section 4.0 concludes the study.

1.1 Technical Literature Background

As far as all these elements are concerned, the Textile scenario looks not so different from the Automotive or Aerospace fields, where PLM represents a powerful tool to be used to support complex systems, as the fast fashion is [22]. Some papers have dealt with the adoption of specific vertical tools and solutions to support product development. Literature is exhaustive, but only in specific fields. In other words, a paper is currently missing which provides an independent study for supporting the integration of collaborative tools and methods within the new textile scenario (fast-fashion) based on user-centred approaches and aimed at catching also latent needs of NPI. A single specimen per typology of paper is reported in the following paragraph, which can be divided (in the order they have been reported) into: Vendor-oriented papers, which underline the technical features of PLM solutions; customer-oriented articles, which analyse the problems that firms face and suggests how to solve them; generic contributions concerning PLM and Apparel which lack scientific methodologies; specific works focused on a single issue and not covering the whole set of problems; white papers of vendors, which promote functionalities. Here, no white paper has been described, as it is not an aim of this paper to promote a specific PLM. A brief synthesis of the findings now follows.

The AMR Research Report [23] aims to show PLM functionalities within the Apparel, Footwear, and Soft Goods industries and to demonstrate, with specific key metrics, the benefits achieved by companies that had invested in PLM software. On the one hand, an exhaustive analysis is conducted of the potentialities of a generic PLM solution and of the differences among different PLM vendors; on the other hand, customers' requirements are not taken into consideration, nor even where and when those PLM functionalities play a role across the product development phase. The report by the Aberdeen Group [24] provides guidance on approaches which had been adopted by successful Textile companies in order to improve operations from concept to delivery for apparel and footwear products. Although it includes several business cases and is customer-oriented, an analysis of the PLM functionalities and how these meet clients' requirements are missing aspects of this contribution. The Kurt Salomon Associate [25] paper helps firms understand the importance of a PLM approach and how to implement it. However, because the analysis is conducted in a generic and philosophical way, it completely lacks a scientific methodology and it

is vague about both customer and vendor sides. Another contribution [26] focuses on showing the different supply chain strategies that Apparel companies can adopt. As the title shows, it is focused on a specific argument and does not cover the whole set of problems that Apparel firms have to face.

2.0 Methodology

The aim of this paper is to provide a clear and objective picture of where and how the use of PLM approach in the Textile world could be helpful.

In order to succeed in this goal, the first step is to capture what NPI processes need. To reach this aim and especially to formalise the latent needs of processes of textile companies, it is necessary to involve a user-centred approach. Thus, a study of textile NPI stakeholders and of their users' viewpoints is needed. Given that each user has a unique view on the system, so as-many-as-possible users should be involved in methodologies and tools analysis and design. So users' activities are to be linked; their needs and perspectives are to be considered from earlier design stages; and their achieved degree of satisfaction is to be tracked [27,28]. This way, textile companies can be more aware of their weaknesses and of desireable improvements that could be undertaken in their processes. Once these elements have been identified, a methodology is needed, able to map these needs with the PLM processes. This step provides a clear, quantitative, and objective map of how PLM processes could impact and support the NPI processes.

Starting from these concepts, an integrated IDEF0-based approach is proposed that formalizes the first steps of textile NPI processes [13]. Some aspects are here underlined: actors involved in each single processes, information/data received and produced, tools/methodologies involved for each process, and possible constraints (box labelled number 1 in Fig.1). IDEF0 [29,30] is useful in establishing the scope of a functional analysis, to show data flow, system control, and the functional flow of lifecycle processes. It supports the requirements definition, functions specification, and the design of an implementation able to fit requirements and to carry-out functions. Each activity is described by a verb-based label placed in a box. Inputs are shown as arrows entering the left side of the activity box; output are shown as exiting arrows on the right side of the box; controls are displayed as arrows entering the top of the box; mechanisms are displayed as arrows entering from the bottom of the box. The choice of IDEF0 is justified by the necessity to provide, during the analysis, a simple and clear scheme that could guide to a shared formalisation of the NPI process.

Starting from a first Desk Analysis [31], a preliminary set of data has been formalised. Then, these data are shared and discussed inside a Focus Group [32], with the involvement of different NPI stakeholders, in order to provide a shared and reliable description of the NPI process and to extract a wider and more consistent set of users' needs along the entire process. A set of structured users' needs has been shared and formalised adopting a AHP strategy [33].

Once a clear picture is outlined of the processes involved in the textile product process and of relative needs, the Quality Function Deployment (QFD) [34] methodology has been adopted in order to correlate the just-obtained textile processes needs with the PLM processes, thanks to the ability of QFD to correlate orthogonal dimensions, i.e. PLM processes and Textile needs (box labelled number 2 in fig. 1). The relationship matrix could be analyzed by the mean of the Independent Scoring Method (ISM) [35] whose aim is to provide a rank of the PLM processes, taking into account the weight which has been assigned to each user requirement.

The findings could be finally used with the LFA [36] strategy as an input to define a set of guidelines for both Textile companies and PLM providers (box labelled number 3 in fig. 1).

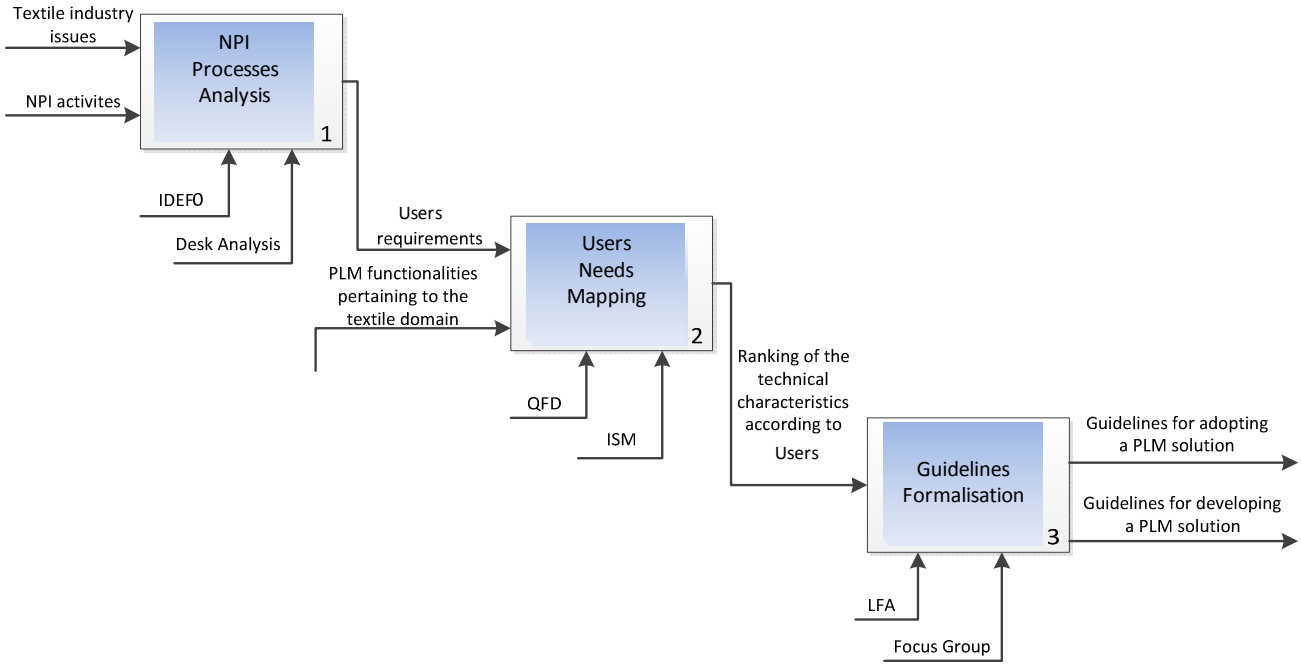

Figure 1: Overview of the proposed methodology.

2.1 New Product Introduction (NPI) Process Analysis: Latent Needs

Starting from a first Desk Analysis [31], a graphical representation of the entire NPI process is shown in Fig. 2 according to the 'outsourcing' strategy. The difference from the 'in-house' strategy is that in the latter there is no 'production outsourcing' activity [37]. Three colours are adopted for the arrows: red stands for constraints, blue for mechanisms, and black for input/output (Fig.2).

The whole NPI process starts with the acquisition of the marketing data, from which a general idea of the collection can be outlined in terms of style, colours, and shapes. Then, through an iterative process, a single sketch/idea per item of the collection is picked among all the choices and developed. Material development and sourcing strategy are conducted along with this activity. After all clothes details are determined, the whole set of information is sent to the production facilities for the quality compliance. The company may choose an outsourcing strategy, i.e. an auction process in which only one or a few suppliers are going to be chosen from a variety of options for the mass production, or an in-house strategy, where the sampling process is internal. When the 'prototypes' are ready and accepted, mass production starts. The activity constraints are: collection calendar, whose most critical issue is TTM; strategic view of the company; environmental regulations; budget. As far as mechanisms are concerned, there are always some IT resources to help the human resources, which can vary as the NPI process unfolds. The role of 'change management' depends on two factors: the market-driven nature of the sector; customers' opinions and preferences. Garments should be modified accordingly, due to close collaboration between all the players in the supply chain, as any outcome of an activity may constitute the mechanism of another activity [38].

Although a detailed analysis has been conducted for each process, here the IDEF0 diagram for the "Design" phase alone is presented as example.

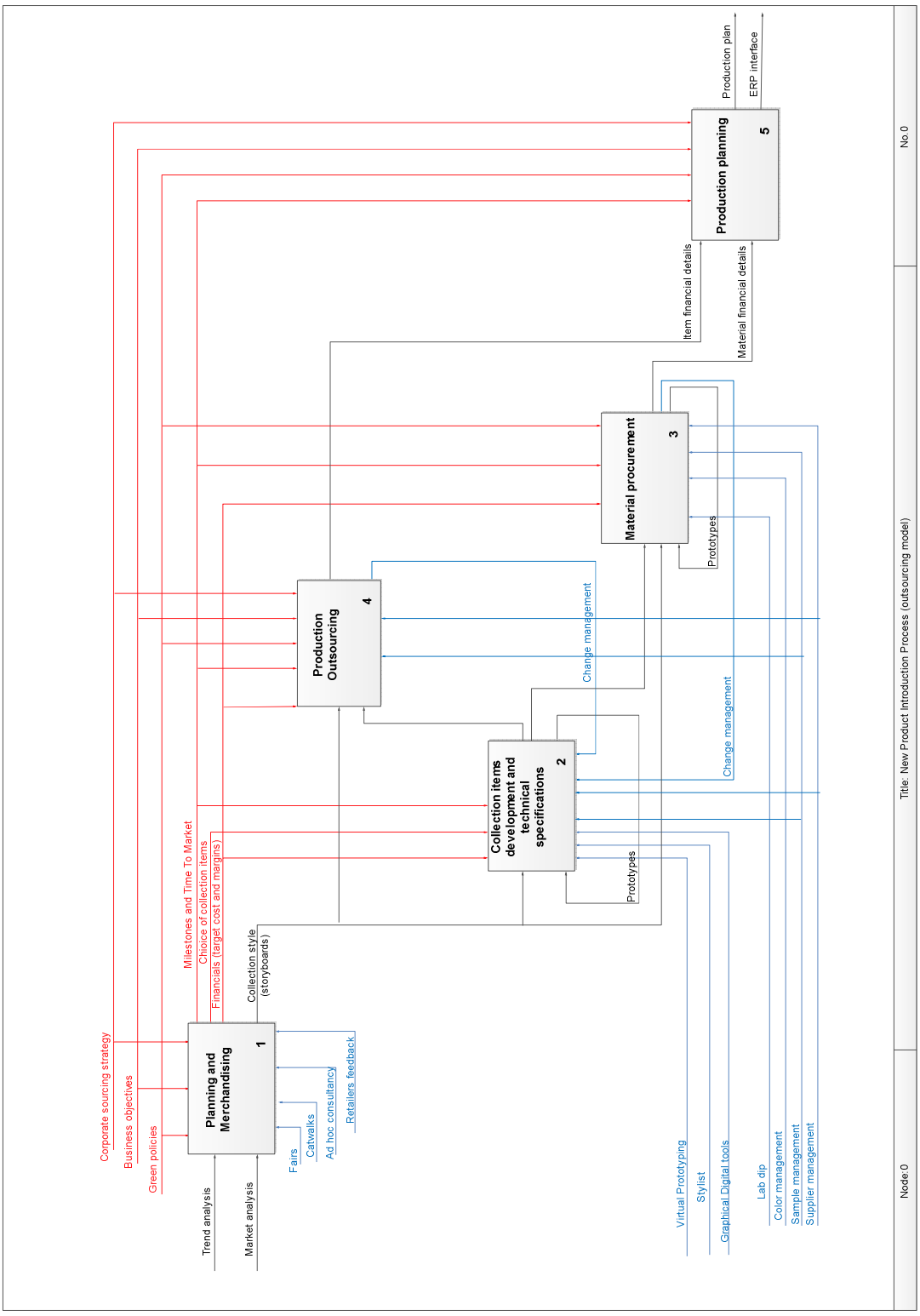

Figure 2: Textile NPI Processes.

Soon after the general ideas of the collection are drawn up in the 'planning and merchandising' activity, several sketches for each item of the collection are made. Stylists are supported by IT solutions peculiar to this industry. As a matter of fact the material is soft rather than rigid; the assembly procedure differs from that of mechanical industry; and, even though the garment is constructed from 2D patterns, the quality of fit is evaluated on 3D human bodies [39]. Hence, nowadays it is possible to generate basic patterns of various sizes and styles using three-dimensional geometric modelling method [40]. It means that stylists

know how much fabric is needed, once parameters such as size and silhouette, which are parametrically modifiable in a 3D CAD environment, are known. This speeds up the design process and reduces the number of physical prototypes. Another important point is the strict collaboration between this process and the 'material & colour development' activity. In this phase, the material/colour palette that is to be assigned to each garment in the collection is set, meaning that a single set of colours may be chosen for each texture. For instance, combinations of cotton and cotton/polyamide, materials in blue, red, and black could be chosen for a man's long sleeved sweater. Cooperation between those two activities has another result, i.e. the study of new materials. Companies are more and more interested in producing alternative materials (new or recycled) to meet environmental regulations, but, at the same time, they need to propose appealing garments. The collaboration between these two activities goes in this direction. Last but not least, the kind of accessorizes that should be incorporated in the collection is defined, so that the supplier selection process can start. The constraints of this activity are basically the outputs of the former activities: calendar deadlines; definition of the collection items; financial targets; green policies (Fig.3). The most important mechanism is the styling, which can be supported by IT solutions such as Adobe Illustrator or specific CAD software (such as Assyst-Bullmer and Dessingsim).

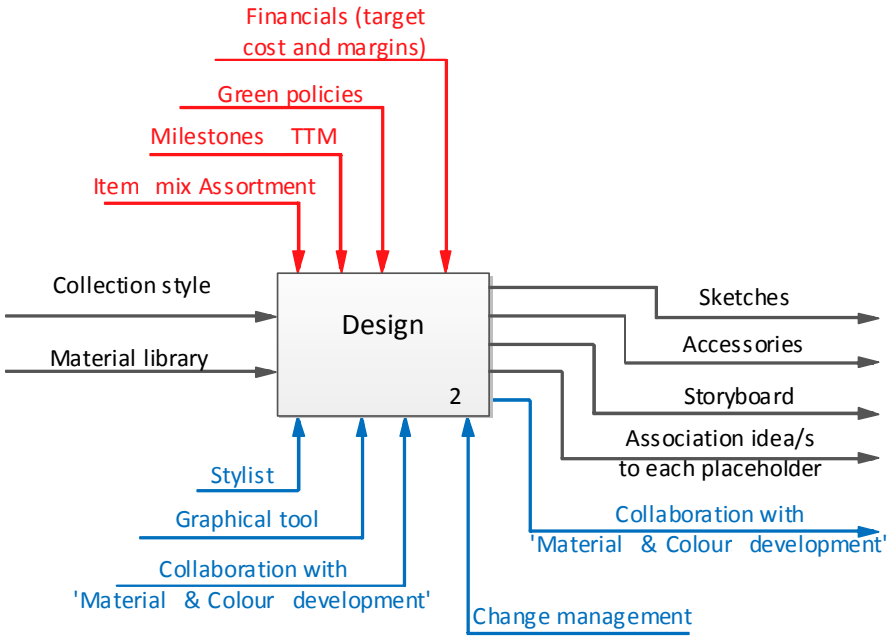

Figure 3: The Design Process (IDEF0).

Once the process was completely formalised (IDEF0), it was shared and discussed inside the Focus Group in order to get a shared process formalisation. The Focus group was composed by thirty stakeholders selected from different NPI processes and different innovative companies. This choice has been run in order to guarantee a positive "innovation behaviour" of the users involved in the analysis and to have as many NPI viewpoints as possible, in order to get reliable analysis results.

Starting from a first brainstorming approach and working on the data coming from the first Desk Analysis, all the suggestions coming from the involved stakeholders have been collected and refined. The sentences have been reformulated in order to identify possible overlapping between the different suggestions and to provide a clearer and more generalised description of the actual needs. (Tab.1)

The same procedure has been used for each single process involved in the NPI, in order to provide a complete map of the issues that arose during the entire NPI process (Tab.2).

Process	User Needs
Design	✓ Supporting the collaboration between Design and Material and Colour Development ✓ Speed up the design process and reduces the number of physical prototypes ✓ Understanding the environmental impact of garments and collections ✓ Supporting access to the graphic documentation of the collections already developed in the company

Table 1: Design Process User Needs.

Process	User Needs
Planning and Merchandising	✓ Supporting development of reliable strategies for anticipating market trends ✓ Supporting young people involvement in the NPI process ✓ Supporting product introduction strategy flexibility ✓ Maintaining a digital record of all the outcomes of each activity
Design	✓ Supporting the collaboration between Design and Material and Colour Development ✓ Speeding up the design process and reducing the number of physical prototypes ✓ Understanding the environmental impact of garments and collections ✓ Supporting access to the graphic documentation of the collections already developed in the company
Choice of the garments in the collection and the development	✓ Supporting data sharing with suppliers/manufacturers in order to reduce costs ✓ Supporting garment data traceability inside the collection ✓ Maintaining under control the alignment with brand rules and customers needs/expectations
Material and Colour development	✓ Supporting the management of numerous samples and lab dips ✓ Trying to limit the use of too many samples ✓ Supporting collaboration tasks between different actors (internal and external)
Supplier Auditing	✓ Supporting the definition of suppliers track records ✓ Supporting the definition of ideal supplier features set ✓ Supporting the design of suppliers comparison tasks
RFQ and supplier bidding process	✓ Supporting an efficient management of all the samples produced by suppliers ✓ Supporting the definition of suppliers track records ✓ Supporting know-how sharing with specialized suppliers

Table 2: NPI Processes User Needs.

Once the list of users' needs was consolidated and shared in the Focus group, it was enriched by adding to each element an importance score. This value moves on a Likert scale [41], from 1 to 5, where 1 was the lowest importance and 5 the highest. The importance scores shown in the final table is the average value obtained by the different stakeholders involved in the Focus Group (Tab.3). This scores are split in two values: Absolute Importance *(A)*, containing the value from 1 to 5 of the Likert Scale; Relative Importance *(R)*, containing a percentage value that shows how much the user need is important compared to the others listed.

USER NEEDS	Absolute Importance *(A)*	Relative Importance *(R)*
Supporting development of reliable strategies for anticipating market trends	5	6.85%
Supporting young people involvement in the NPI process	5	6.85%
Supporting product introduction strategy flexibility	5	6.85%
Maintaining a digital record of all the outcomes of each activity	3	4.11%
Supporting the collaboration between Design and Material and Colour Development	5	6.85%
Speeding up the design process and reducing the number of physical prototypes	4	5.48%
Understanding the environmental impact of a single garment or of the collection	3	4.11%
Supporting access to the graphic documentation of the collections already developed in the company	3	4,11%
Supporting data sharing with suppliers/manufacturers in order to reduce costs	3	4.11%
Supporting garment data traceability inside the collection	4	5.48%
Maintaining under control the alignment with brand rules and customers needs/expectations	4	5.48%
Supporting the management of numerous samples and lab dips	4	5.48%
Trying to limit the use of too many samples	3	4.11%
Supporting collaboration tasks between different actors (internal and external)	4	5.48%
Supporting the definition of suppliers track records	4	5.48%
Supporting the definition of ideal supplier features set	4	5.48%
Supporting the design of suppliers comparison tasks	3	4.11%
Supporting an efficient management of all the samples produced by suppliers	3	4.11%
Supporting know-how sharing with specialized suppliers	4	5.48%

Table 3: NPI User Needs and Relative Importance.

2.2 Users Needs Mapping: User Needs vs PLM Processes

Once the NPI process is formalised, together with users' needs, it is necessary to quantify how much the just-obtained user needs match with the PLM processes. In order to get a more reliable picture of this scenario, the main PLM processes have been declined describing the main features each process could provide. This provides the focus group with a clearer idea of PLM. Moreover, in order to run an objective analysis, the PLM feature list has been extended by introducing in the analysis also the features of other IT solutions actually involved in the textile domain. These are: Collaborative Demand Management (CDM) and Enterprise Resource Planning (ERP). This way, it is possible to understand which role PLM plays in the NPI processes compared with other available solutions.

Starting from a first desk analysis [42 - 53], a generalised set of PLM, CDM, ERP processes have been formalised providing some key features (Tab.4).

Each process has been correlated with users' needs through the correlation matrix of the QFD approach. Again, instead of providing each stakeholder matrix, the final one with median values was provided (Tab.5). In order to support the readability of the matrix, the IT processes have been replaced by a correspondent alphabet letter, as explained in Table 4. Each user need has been analysed in order to identify whether a correlation with one or more IT processes exists. If the correlation is proved, it is quantified moving on three values: 1, 3, 9. Value 9 is employed if the correlation is very strong, 3 is provided if the correlation is medium, while 1 is involved only if the correlation rate is very low.

The **Independent Scoring Method (ISM)** has been applied to the correlation matrix in order to provide a IT processes ranking and a tangible value of how much that process impacts on NPI (Tab.5).

PROCESS	FEATURES
Trend Analysis (a)	✓ Supporting the reuse of history from old ranges and styles
	✓ Supporting sensing tasks about garment and collections
Demand Forecasting (b)	✓ Providing multi level forecasting such as range or style
	✓ Supporting mathematical forecasting techniques based on sales statistics to generate forecast for continuity products
Market Segmentation (c)	✓ Providing the design of segmentation strategies
	✓ Supporting multichannel surveys
Project Management (d)	✓ Providing every stakeholders with project progress status, through live dashboards and reports ✓ Planning, executing, monitoring and controlling complex development processes spread across globally distributed project, product, and technological teams;
Environmental Performance Management and Regulatory Compliance (e)	✓ Developing, codifying, and maintaining a proactive corporate standard ✓ Supporting due diligence for regulatory authorities and meet customer requirements.
Quality and reliability management (f)	✓ Supporting concurrent FMEA and past experiences analysis for identifying critical components and mitigation plan ✓ Estimating maintainability costs early and continuously, on the basis of the predicted availability, repair logistics and sparing strategies
Change and configuration management (g)	✓ Supporting Stakeholders to access product data/information during evaluation, review, approval, and implementation of changes phases ✓ Recording all the changes made over the complete product definition associating the revision and iteration history
Engineering (h)	✓ Supporting the collaboration between different company department managing cross-discipline product information/data ✓ Providing traceability between the requirements, test cases, design configurations, test configurations and results
Sourcing (i)	✓ Supporting collaboration with suppliers to identify the cost drivers and enable early mitigation strategies for any critical components ✓ Providing a secure workspace for all the suppliers for guaranteeing updated data/information ✓ Supporting the supplier qualification process standardisation
Manufacturing management (l)	✓ Transforming engineering-bill-of-material (eBOM) into multiple plant-specific manufacturing-bill-of-materials (mBOM) while maintaining bidirectional traceability ✓ Transforming 3D design into a set of specific instructions (part program) for a single work centre while bidirectional traceability ✓ Automating release-to-production through an ERP or MES system
Sales Analysis (m)	✓ Supporting store transaction on-line analysis
	✓ Defining Sales Tax Rules, Customs & Excise Rules for item
Warehouse Management (n)	✓ Tracking materials batches
	✓ Providing different methodologies for inventory management
Purchase Management (o)	✓ Defining payment terms and standard purchase terms
	✓ Managing the request for quotation to vendors

Table 4: IT solutions Process and Relative Main Features.

		IT Processes												
User Needs	*A*	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**l**	**m**	**n**	**o**
Supporting development of reliable strategies for anticipating market trends	**5**	9	9	9					3	3				
Supporting young people involvement in the NPI process	**5**													
Supporting product introduction strategy flexibility	**5**	3		3	9			3	3	3				
Maintaining a digital record of all the outcomes of each activity	**3**				3			9	1	1				
Supporting the collaboration between Design and Material and Colour Development	**5**				3			3	9	3				
Speed up the design process and reduces the number of physical prototypes	**4**				3			3	9	3				
Understanding the environmental impact of a single garment or of the collection	**3**					9		3	3	3				
Supporting access to the graphic documentation of the collections already developed in the company	**3**					3		9	3	9				
Supporting data sharing with suppliers/manufacturers in order to reduce costs	**3**				1			3	3	9	1			
Supporting garment data traceability inside the collection	**4**							9				9	3	
Maintaining under control the alignment with brand rules and customers needs/expectations	**4**				3	9		3						
Supporting the management of numerous samples and lab dips	**4**				9			9	1	3		9	9	9
Trying to limit the use of too many samples	**3**				3			3	9	1				
Supporting collaboration tasks between different actors (internal and external)	**4**				1			9	9	9				
Supporting the definition of suppliers track records	**4**							1		3				
Supporting the definition of ideal supplier features set	**4**						1	3	3	9				
Supporting the design of suppliers comparison tasks	**3**									3				
Supporting an efficient management of all the samples produced by suppliers	**3**				9			9		9				
Supporting know-how sharing with specialized suppliers	**4**							3		9				
		4%	**3%**	**4%**	**12%**	**5%**	**0.3%**	**22%**	**16%**	**21%**	**0.2%**	**5%**	**3%**	**3%**

Table 5: QFD correlation matrix (*user needs vs IT processes*).

3.0 Guidelines Formalization: where and how PLM processes provide benefits

The aim of this section is to exploit the results coming from the QFD correlation matrix and from the ISM method for providing a set of guidelines supporting textile companies to quantify where and how much the PLM process impacts the NPI process.

Thanks to the results coming from ISM analysis (Tab.6), it is possible to see that the IT processes that show a significant impact on the NPI processes, over 10%, are: **Change and Configuration Management, Sourcing, Engineering and Project Management**. This information underlines the necessity to invest in these IT processes to concretely support the NPI performances. In fact, the above mentioned IT processes are associated with a 70% value in terms of impact on company user needs.

Going ahead with the analysis of the data coming from ISM results, it is possible to evaluate which is the global impact that every analysed IT solution has on the NPI process requirements. Starting from PLM, the value reached is around 76%; CDM is 12%; ERP is 12%. This means that NPI processes requirements could not be covered only by one IT solution, even if PLM represents the best in class. The data coming from the analysis highlight that a real integration between the different IT environments is mandatory in order to help improving performance and consequently to support an efficient adoption of PLM within the textile domain. Without a real collaboration environment between the different company areas and IT platforms, the NPI stakeholders miss key information and data useful for their tasks. This means that significant benefits could not be obtained.

Having a look to the rank provided by the ISM it is possible to see that **Change and Configuration Management** represents a key feature for the NPI process. From a deeper analysis developed inside the Focus Group, it has been understood that, by providing an online platform that allows every player involved in the supply chain to have access to real/updated data 24/7, Textile companies could respond to the volatility behaviour of their market, as they can react suddenly to changes in an effective and efficient manner, even though the supply chain is long and complex. The presence of many garments inside different collections managed by different company actors and suppliers amplifies the importance of this process inside the textile scenario.

IT Processes	Absolute importance	Relative importance	Rank
Trend Analysis	82	4%	6
Demand Forecasting	62	3%	7
Market Segmentation	82	4%	6
Project Management	**236**	**12%**	**4**
Environmental Performance Management and Regulatory Compliance	99	5%	5
Quality and reliability management	5	0.3%	8
Change and Configuration Management	**408**	**22%**	**1**
Engineering	**301**	**16%**	**3**
Sourcing	**403**	**21%**	**2**
Manufacturing	4	0.2%	9
Sales Analysis	99	5%	5
Warehouse Management	66	3%	7
Purchase Management	49	3%	7

Table 6: IT processes ranking according to the Independent Scoring Method (ISM).

Also **Sourcing** globally plays an important role on the entire NPI process, as an efficient collaboration with the right suppliers is the only way to arrive on the market with the right garment and collections at the right time.

While the previous analysis developed on the data coming from ISM showed the key role of PLM and of those processes that are more important from the NPI viewpoint, going ahead with the QFD correlation matrix, it is possible to have a more detailed picture/map about where and how the PLM processes impact the different NPI processes (Tab.7). Working with the value contained in the different cells, a quantification of this impact can be provided.

Moreover, for each NPI process, a set of Key Performance Indicator (KPI), supporting a tangible evaluation of the benefit reachable, is provided.

Processes	PLM Processes	Impact KPI
Planning and Merchandising	✓ Change and Configuration Management ✓ Project Management	✓ unsold garments in the warehouse ✓ number of changes for each garment and collection ✓ number of garments not aligned to the customers' need ✓ number of garments late on the market
Design	✓ Engineering ✓ Sourcing ✓ Environmental Performance Management and Regulatory Compliance ✓ Change and Configuration Management	✓ time spent for accessing product data ✓ number of sample discarded ✓ time spent for not core tasks, that do not produce added value
Choice of the garments in the collection and the development	✓ Engineering ✓ Sourcing ✓ Environmental Performance Management and Regulatory Compliance ✓ Change and Configuration Management	✓ Number of non correct information provided to the supplier ✓ Number of garments and collection that do not respect the company brand specifications
Material and Colour development	✓ Engineering ✓ Project Management ✓ Change and Configuration Management ✓ Sourcing	✓ Number of not achievable manufacturing tasks asked by Design (not feasible on the specific material,...)
Supplier Auditing	✓ Sourcing ✓ Change and Configuration Management	✓ Number of selected suppliers
RFQ and supplier bidding process	✓ Sourcing ✓ Change and Configuration Management	✓ Number of waste produced by the supplier that do not respect the company standards

Table 7: PLM vs NPI process and relative Key Performance Indicators.

Starting from **Planning and Merchandising,** where the nature of the market and the impossibility to predict customer preferences trends forces the company to adapt their production at any time, **Change and Configuration Management** plays a fundamental role due to the necessity to manage, in a very short time, different company scenarios. Together with this aspect, **Project Management** plays a significant role in this NPI stage, as calendar and milestone management represents a key feature for maintaining all the NPI processes under control and for supporting TTM reduction. It should be pointed out that the companies in this sector need to plan activities for hundreds, or even thousands, of different products per collection, season after season. To complicate matters even more, firms have to deal with diverse calendars (apart from the 'season' and 'product' distinction), as certain activities are performed in different countries. Companies need to define a Seasonal and Product calendar, based on Season or type of Product. Moreover, calendar tasks should be created, including duration, start-data, precedent tasks and methods for associating planned with achieved dates. Calendar tasks should also identify what is on schedule, what has the potential to be late, or is past. A count/percentage of product completion should be mapped and

reported. It is also important that the right garment is sold in the correct season, that a huge product portfolio could be managed in a reliable and efficient way, and that all possible events in the product lifecycle are correctly monitored and tracked. Working with the right methodologies and tools is possible to get significant benefits reducing the following wastes: *unsold garments in the warehouse, number of changes for each garment and collection, numbers of garments not aligned to the customers' need, number of garments late on the market*.

Moving ahead with the NPI stages and analysing **Collection Items Development and Technical Specifications**, that contains **Design** and **Choice of the garments in the collection and the development** stages, where the necessity to move inside flexible design strategies represents a key element, **Engineering** features, as for instance Product Definition Tools, could support product definition in a more efficient and interdisciplinary way. Without the possibility to support a concurrent design strategy, where for instance style is defined together with material and colour, the right product could not be reached. The strong correlation that exists between textile company and its suppliers, already in the design phase but surely in the development one, is the reason why there is also a strong correlation between this NPI phase and **Sourcing**. The actual attention to "Green" justify the correlation of this stage with **Environmental Performance Management and Regulatory Compliance**, as during the first product lifecycle stages it is necessary to verify that all the environmental constraints and the brand management aims are correctly fitted. Here also **Change and Configuration Management** plays an important role due to of the necessity to provide all internal and external players with up-to-date product information, but also with catch best practise and critical points for supporting both future NPI process and reuse of already developed garment in new collections. The involvement of efficient strategies and right tools could provide significant benefits in term of reduction of: *time spent for accessing product data, number of sample discarded, time spent for not core tasks, that do not produce added value, number of non-correct information provided to the supplier, number of garments and collection that do not respect the company brand specifications.*

In **Material and Colour Development** there is a strong correlation with **Engineering** features, as the tasks are developed by many interdisciplinary actors involved in the product definition. In this phase, many tests are developed and Lab dip are produced. In order to maintain a correct track of this activities, the textile company needs a structure **Project Management** strategy. This could provide benefits in terms of *number of not achievable manufacturing tasks asked by Design (not feasible on the specific material,...)*.

In the last phases that deal with **Supplier** management, a direct correlation is created with **Sourcing.** It is mandatory to create a close collaboration between all players at any point in the NPI process. The accomplishment of this task will result in the sharing of know-how among different internal and external departments in the Textile company. This would entail the delivery of a high quality product at a reasonable price, which is what customers want. Sharing confidential information may seem unsafe, but there are several tools in PLM solutions that guarantee the access of data only to some selected people, with the agreed restrictions. Globalization has introduced several benefits, such as the possibility of choosing among a wide variety of trade-offs between time, cost, and quality. However, among the infinite number of choices, which one fits the needs of the Textile company the best? Firms need a reliable tool to make these strategic decisions and can no longer rely on instinct and/or the capacity of its employees. It is necessary to transmit this knowledge and de-codify it, so that the company does not suffer when some people leave the firm. 'Vendor scorecards' respond to these needs. Its functionalities enable companies to evaluate the most important features of any supplier; giving a global value allows firms to easily evaluate different solutions. Nonetheless, it is important to highlight that a software will never be comparable with the skills and capacities of veterans in the sector. What has been pointed out is that vendor scorecards may be a valid instrument to support Textile companies in the decision making process.

This means that suppliers management could benefit in terms of reduction of: *number of selected suppliers, number of waste produced by the supplier that do not respect the company standards.*

Moreover, proceeding with the analysis of the QFD matrix it is possible to see that "*Supporting young people involvement in the NPI process*" has no correlation with the IT processes. This means that no IT processes is able to respond to this need. It means that IT vendors should invest in this direction identifying an innovative solution for capturing data from young people, for instance through efficient interaction with social media, where normally young people discuss about fashion topics too.

4.0 Conclusion

The proposed methodology proved that PLM could provide benefits to the textile domain. Also, a map of where and how the PLM processes could give benefits to the NPI process was provided.

Together with a quantification of the impact that the specific PLM process has on the specific NPI process, a set of key performance indicators has been defined, in order to support the textile company in understanding which are the obtainable tangible benefits. This way, they could have a clearer and objective picture of what they can expect from PLM and if this is what they need.

The analysis results also highlighted that, for boosting PLM in the textile domain, it is necessary to create a "collaborative environment" where data are spread between different platforms, but always linked, updated, and reachable by all internal or external stakeholders (suppliers,...) of the NPI process. Without this synergy, NPI stakeholders miss product information, driving the company to an inefficient process management. This means that an efficient and integrated PLM solution could concretely be a real suitable solution for supporting a textile company to improve its performances, as maintaining NPI processes under control means have TTM under control.

Moreover, the actual PLM processes could be improved by investing in the interaction with social media. This new element could support the involvement of young people in the NPI process and having in real-time more data about the market for guaranteeing the right garment at the right time to the product.

5.0 References

1. Alemanni M., Grimaldi A.,Tornincasa S., Vezzetti E., *Key performance indicators for PLM benefits evaluation: The Alcatel Alenia Space case study,* Computer in Industry 2008, Vol. 59, pp. 833 - 841

2 Violante M.G., Vezzetti. E., A methodology for supporting requirement management tools (RMt) design in the PLM scenario: An user-based strategy, Computers in Industry, Volume 65, Issue 7, September 2014, Pages 1065–1075

3. CimData, *Product Lifecycle Management "Empowering the Future of Business*, 2002. http://www.cimdata.com

4 Vezzetti E., Violante M.G., Marcolin F., A benchmarking framework for product lifecycle management (PLM) maturity models, The International Journal of Advanced Manufacturing Technology March 2014, Volume 71, Issue 5-8, pp 899-918

5. Bokinge M., Malmqvist J., *PLM implementation guidelines – relevance and application in practice: a discussion of findings from a retrospective case study,* Int. J. of Product Lifecycle Management, 2012 Vol.6, No.1, pp.79 – 98

6 Vezzetti E., A knowledge reusing methodology in the product's lifecycle scenario: a semantic approach, International Journal of Manufacturing Technology and Management (IJMTM), Vol. 26, No. 1/2/3/4, 2012

7. Ming X. G.,Yan J. Q, Lu W. F., Ma D. Z., *Technology Solutions for Collaborative Product Lifecycle Management – Status Review and Future Trend,* Concurrent Engineering, 2005; vol. 13, 4: pp. 311-319.

8. Bouikni N., Rivest L., Desrochers A., *A Multiple Views Management System for Concurrent Engineering and PLM,* Concurrent Engineering, 2008; vol. 16, 1: pp. 61-72.

9 Guerra, A.L., Gidel, T., Kendira, A., Vezzetti, E., Jones, A., Co-evolution of design tactics and CSCWD systems: Methodological circulation and the TATIN-PIC platform, Proceedings of the International Conference on Engineering Design, ICED 9 DS75-09, pp. 315-324

10 Vezzetti, E., Moos, S., Kretli, S., A product lifecycle management methodology for supporting knowledge reuse in the consumer packaged goods domain, Source of the DocumentCAD Computer Aided Design

43 (12), pp. 1902-1911

11. Etienne A, Guyot E., Wijk D., Roucoules L., *Specifications and development of interoperability solution dedicated to multiple expertise collaboration in a design framework,* Int. J. of Product Lifecycle Management, 2011 - Vol. 5, No.2/3/4 pp. 272 – 294

12. Pol G., Merlo C., Legardeur J., Jared G., *Implementation of collaborative design processes into PLM systems,* Int. J. of Product Lifecycle Management, 2008 - Vol. 3, No.4 pp. 279 – 294

13. Sull, D. and Turconi, S., *Fast fashion Lessons*. Business Strategy Review, 2008, Vol.19, No. 2, pp. 4-11

14. Bruce M., Daly L., *Lean or agile. A solution for supply chain management in the textiles and clothing industry?* , International Journal of Operations and Production Management, 2004, Vol. 24, No. 2. Pp. 151 – 170

15. Keenan M., Saritas O., Kroener I., *A dying industry or not? The future of the Eruopean textiles and clothing industry*, 1999, Foresight. Vol. 6, No.5, pp. 313 - 322

16. Grey. L, *Primark effect' prompts government drive to cut clothes sent to landfill.,* The Telegraph. 20th February 2009.

17. Crean, S. and Doeringer, P**.,** *Can fast fashion save the U.S. apparel industry?,* Socio-Economic Review, 2006, Vol. 4, No.3, pp. 353 – 377.

18. R. Bandinelli, S. Terzi, Progettare prodotti di lusso: ruolo dei sistemi informativi PLM nel settore moda, Progettare i prodotti del futuro, edizioni Este, 2012

19. The Agile Supply Chain : Competing in Volatile Markets, Martin Christopher (Cranfield School of Management, UK), Industrial Marketing Management, Vol 29., No. 1., 2000

20. Crofton, S.O. and Dopico, L.G., *Zara-inditex and the growth of fast fashion*, Essays in Economic and Business History, 2006, Vol. 25, pp. 41-53

21. The Quick Response Management System: Structure and Components for the Apparel Industry, D. H. Kincade, N. Cassill & N. Williamson, The Journal of The Textile Institute,Volume 84, Issue 2, 1993

22. Christopher, M., Lowson, R. and Peck, H., *Creating Agile supply chain in the textile industry*, International Journal of Retail and Distribution Management, 2004, Vol. 32, No.8, pp.367 – 376

23. Evans M., Bythe J., *Textile: a new paradigm of consumer behaviour,* Journal of Consumer Studies & Home Economics, 1994, Vol. 18, No. 3, pp. 229–237

24. Barrett M., Suleski J., Burkett M., *PLM for Apparl, Footwear and Soft Goods: meeting the demands fo New Product Introduction.,* AMR Research, 2007, http://www.gartner.com/id=1340490

25. Jackson M., *Integrated Design-to-Delivery for fast fashion: On-time, On-Trend and On-Profit.*, Aberdeen Group 2009, http://aberdeen.com/Aberdeen-Library/5995/RA-design-delivery-textile.aspx

26. Rubman J., *The three stages of Retail PLM adoption.* Kurt Salomon Associates, 2011, http:// www.kurtsalmon.com/

27. Génova, G., et al., A framework to measure and improve the quality of textual requirements. Requirements Engineering, 2013. 18(1): p. 25-41.

28. Schwaber, C. and P. Sterpe, Selecting The Right Requirements Management Tool–Or Maybe None Whatsoever. Forrester Research. Inc.,(2007, 28th September), 2007.

29. Presley A. Liles. D., *The Use of IDEF0 for the Design and Specification of Methodologies.* 4th Industrial Engineering Research Conference, Nashville 1995. pp. 442-448.

30. Colquhoun, G.J., Baines, R.W. and Crossley, R. A state of the art review of IDEF 0. *International Journal of Computer Integrate Manufacturing*, 1993, Vol. 6, No. 4. pp. 252 – 264

31 Brusoni G., Lazzaretti L., Ricerca empirica e management : il contributo delle metodologie statistiche, - Firenze : Firenze University Press, 2003.

32. Martakis, A., Handling requirements dependencies in agile projects: A focus group with agile software development practitioners, Research Challenges in Information Science (RCIS), 2013 IEEE Seventh International Conference on, 29-31 May 2013, Paris, pp. 1 – 11

33 Vaidyaa O.S., Kumarb S., Analytic hierarchy process: An overview of applications , European Journal of Operational Research Volume 169, Issue 1, 16 February 2006, Pages 1–29

34. Chan L., Wu M., *Quality Function Deployment: a Comprehensive Review of Its Concepts and Methods,* Quality Engineering, 2002, Vol. 15, No. 1, pp. 23 - 35

35. MacCarthy B., Jayarathne, P**.,** *Fast fashion: Achieving Global Quick Response (GQR) in the Internationally Dispersed Clothing Industry*. Innovative Quick Response Programs in Logistics and Supply Chain Management International Handbooks on Information Systems 2010, pp 37-60

36 Jaca C., Galeano L., Viles E., Mateo R., Santos J., *The Logical Framework Approach and Worker Commitment*, Managing Complexity, Lecture Notes in Management and Industrial Engineering 2014, pp 43-49

37. Schwigert M., *Mountains of textile trash, most bound for the landfill*, *Lancaster online. 10th* June 2011.

38. Nakhata C., *Market-Driven supply chain management: a Sustainable competitive advantage in the textile Apparel Industry*, Executive Journal, 2008, pp. 39 - 44

39. Yong-Jin Liu, Dong-Liang Zhang, Matthew Ming-Fai Yuen, A survey on CAD methods in 3D garment design, Computers in Industry 61 (2010) 576–593

40. Sungmin Kim, Chang Kyu Park, Basic garment pattern generation using geometric modeling method, International Journal of Clothing Science and Technology, volume 19 issue 1, 2007

41. Akao Y., Mazur G., *The leading edge in QFD: past, present and future.* International Journal of Quality & Reliability Management Vol. 20, No. 1, pp 20 – 35.

42. Centric., *A PLM solution Designed for Apparel and Fast Moving Consumer Goods Companies,* 2012. http://www.centricsoftware.com

43. Dassault Systèmes, *Enovia: development & sourcing Platform*. 2012, http://www.3ds.com

44. Dassault Systèmes, *Web Site Company Dassault Systèmes.* 2013. http://www.3ds.com.

45. PTC, *FlexPLM, comprehensive PLM for retal, footwear & apparel and consumer products*, 2012, http://www.ptc.com

46. PTC, *Web Site Company Parametric Technology*, 2013, http://www.ptc.com

47. PLM Systems, *Diffusione del PLM nel settore della moda: lo stato dell'arte,* IT4ashion, Firenze 2013

48. Centric, *Centric 8 PLM Software*, 2013, http://www.centricsoftware.com

49. TXT, *TXTe-solutions Demand & Supply Chain Management – TXTPerform, 2008*, http://www.txtgroup.com

50. SAP, *Business All.in-One - Textile for AFS*, 2012, http://www.global.sap.com.

51. Lectra, *Design to Cost: a holistic approach to Controlling Development Cost*, 2013, http://www.lectra.com

52. Siemens, *Solutions for smarter decisions in Apparel and Footwear*, 2012, http://www.siemens.com/plm

53. Cegid, *Your cegid retail*, 2013, http://www.cegid.fr