Implementation of Design for Six Sigma on Mass-Customization Companies

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Abstract

The role of quality control is to correctly translate customers’ requirements into materialized products to achieve customers’ satisfaction. Today Product Development Process (PDP) becomes the stage to improve and to obtain successful products. In the 1980s, Six Sigma appeared as an attempt to improve some aspects of products and services in order to reduce failures in production as much as possible. But there still was a lack of customer perspective over product development project. This thesis approached the lack of customer insight with a new product development process, Design for Six Sigma (DFSS). Examples that describe how DFSS works and its implementation are still missing, therefore the purpose of this master thesis is to prove if the implementation of DFSS would be efficient, effective and closer connected to the customer of mass- production companies. DFSS is based on processes, roles and tools. However, it is questionable whether the suggested role structure and a uniformed process are able to implement in the real world.

The methods used for this research project were two interviews with two mass customization companies, qualitative data collection and finally analyzing the collected data by comparing them with the theory of DFSS. This PDP ensures the track, and enhances creativity and innovation, taking the process beyond its capabilities. Moreover, the conclusions of the thesis show that there is no need for a uniformed model, making DFSS more useful and trickier for competitors. The lack of a uniformed model allows to overcome the innovative ability. The skills to reach these roles and the creation of a team within the company are more important than roles and backgrounds themselves. In spite of knowledge of expertise areas, the task is more related to control the collaboration, communication and flow of information within the group. DFSS becomes a successful solution for customer insight, a good combination of tools and techniques. But it does not mean that implementing accurately a certain methodology is the right solution.
Glossary

DFSS- Design for Six Sigma
PDP- Product Development Process
GPDP- Group Product Development Process
TQM - Total Quality Management
QCs- Quality Characteristics
PDCA- Plan Do Check Act
DCOV- Define, Characterize, Optimize and Verify
DMADIC – Define, Measure, Analyze, Design, Implement and Control
DCCDI- Define, Customer, Concept, Design and Implement
DMADV- Define, Measure, Analysis, Design, Verify- DFSS model
DMADOV- Define, Measure, Analyze, Design, Optimize and Verify
DMEDI – Define, Measure, Explore, Develop and Implement
ICOV- Identify, Characterize, Optimize and Validate
QOL- Quality of Life
GPD- Gross Domestic Product
PQLI- Physical Quality of Life Index
CE- Customer Experience
DM- Data Mining
LTM- Life Time Value
MBTI- Myers Briggs Test Indicator
CP- Check Point
SCR- Support Center Register
QFD- Quality Function Deployment
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INTRODUCTION

1.1. Background

The founder of Wal-Mart, Sam Walton, said: "There is only one boss. The customer. And he can fire everybody in the company from the chairman on down, simply by spending his money somewhere else."

The world is formed by more than 194 countries, 194 is the indebted number and more than millions of companies that control a wide and repetitive portfolio. It creates a global market that is continuously growing and they have to compete and be the customers’ choice to survive. Quality became the point to reach customers and achieve satisfaction. Customers became the main factor for the companies and their strategies.

However, once everyone achieves an environment of quality, something distinct has to appear to differ from companies and allow customers to have a choice. New Product Development Processes are introducing a new perspective to bear on mind customers from the beginning through a set of tools. New Product Development Processes are enhancing workers to create a team to manage the Product Development Process and get the wished outputs. The efforts are varying to get benefits over the whole process and to take processes beyond its design capabilities, by turning innovative ideas into customized and marketable products. The figure 1 shows the change of efforts from typical patterns to new methodologies such as Design for Six Sigma.

![Fig.1. Changing efforts by using the Design Methodology [1]](image)

DSFF is a quality methodology which tries to approach the customers’ expectations and wishes, making the process of the product development in an effective and efficient manner at the same time. DFSS is supported by a toolbox, roles and process. Currently there are not any studies about companies that have already implemented DFSS completely.

1.2. Goal

The objective/purpose of this master thesis project is to discover how an adoption of DFSS could affect the companies, getting information and studying the case of two companies. The implementation of DFSS could be interesting for these companies; by Interesting it is meant that DFSS implementing could make the company more efficient, effective, and closely connected to the customer. Maybe this opportunity is impossible to be carried out
due to resource constraints, or the implementation should be done in a different way, depending on the chosen companies.

The research will be focused on two companies in order to get into their problems and opportunities. Companies will be mass-production and research will be focused on product development and innovation. The choice of this kind of companies is due to the fact that the implementation could directly affect these companies because the complexity of processes carried out by them, and also because they launch several products to the market.

1.3. Restrictions

This master thesis is focused on the application of DFSS in the product development processes, by showing how it affects the companies, within a limited period to study an amount of unlimited information. The conclusion is achieved thanks to the comparisons of the theoretical part with current processes in both mass-customization companies. Due to the choice of only two companies, the results are very limited and they cannot be widespread easily; it should still try to generalize the results to be useful for other companies. Comparisons are superficial and qualitative, so there is a lack of quantitative data that could be more obvious to get conclusions. This case study provides useful information to know how companies are controlling their product development processes; and the tools that DFSS could offer to mass-customization companies to support their processes and approach to customers’ satisfaction. Therefore, this document should be complemented to obtain a good overview of DFSS. In this master thesis two perspectives have been set, these are the initial hypotheses. However there are other perspectives of DFSS that these two hypotheses.

1.4. Hypotheses

These two hypotheses have been chosen due to the need to prove the implementation of DFSS. DFSS is based on role structure, tools and techniques and processes; therefore it is necessary to study the following hypotheses to implement DFSS and look for how these hypotheses could affect the companies.

H1: There is no need for a uniformed Product Development (PD) process model

In the current situation most organizations and authors base their DFSS process descriptions on different PD process models. Nevertheless, the DFSS concept aims at identifying one optimal PD process model. Since the current status is that several different process models are used it can be questioned whether a unified model is needed and if it really can be identical in all organizational applications.

H2: The core roles of DFSS are unrealistic to implement in the real world

The DFSS role structure provides new organizational ideas to the PD field including among others a DFSS Black Belt. On the other hand, these new kinds of roles are aimed to quality engineers rather than product developers, allocating a wide knowledge range of organization’s development process. It is questionable whether this knowledge range can be controlled by quality professionals.
2. METHODOLOGY

2.1. Choice of the Methodology

The procedure/method to carry out the process is as the one used in a case study; it is based on qualitative information. It follows a logical line through different phases to reach the goal which is to answer the initial hypotheses and to obtain a conclusion about DFSS’s implementation. It should allow moving forward the line, in a reliable and valid way. The followed line is shown through the figure 2.

![Fig.2. Phases of the project](image)

2.2. Literature’s review

In order to make students familiar with the concept it is necessary a literature review of the fields that are covered by DFSS. The framework of this review could look like an iterative cycle. The initial step of this cycle is mainly to look for the key words that will be the base line to support the thesis and to build the complete concept of DFSS. The iterative circle is presented by the figure 3. The key words arise from the articles, books and thesis related to the topic, which can influence the studied objective, all of them will be considered. The articles were searched for on web-sites and the purpose is to choose actual and relevant articles (from 2000). When an article is chosen, there are some other recommended articles that also can be useful. In these documents, new key words were found and the circle started again.

In order to get a successful research, the researcher should be motivated and inquired to complete the whole perspective, and it will be the base line for the data collection and analysis of data. This literature is compiled, and specific concepts and theories are taken in order to create the final report and support the final conclusions.
Once the literature is compiled, the student was ready to explain the theoretical part that will support the final conclusions. It will help to understand clearly the different fields, and to build up a complete background. Sometimes the theory was not so evident, and the student had to restart the prior cycle: literature review, in order to clear up [2]. The theoretical part is explained in different fields and these fields will be the mainstays of the two interviews.

Interview´s questions emerged while the theoretical part was being written, by pointing out the most important aspect to understand processes within the companies and then comparing these aspects with the theoretical findings [2].

2.3. Data Collection

Thus, data were provided by interviews [3], [4]. The choice of interviewees was limited to two international Swedish companies and it was based on the idea of selecting important roles within these organizations that could provide a good perspective about PDP. The proximity to domestic customers is lower in bigger companies (mass-production). A deep customization needs to know the customer needs exhaustively. Therefore, it became a perfect opportunity to study the DFSS´s application in these companies. The first contact with both interviewees was by phone and then a meeting was organized to do the interviews. The first contact was quite easy and they were willing to help.

The content of the interviews fit the thesis´ needs. It was structured in different fields related to the Master Thesis´ topic, consequently making the extraction of later conclusion easier. It was a mixture between loose- questions and tight questions, it was a converging- questions approach. [3]. The different fields are:

- Quality
- Product Development
- Customer satisfaction
- Innovation
- Roles Structure
Questions emerged from the theoretical part, once it was almost defined and explained. It was a semi-structured interview; on the one hand it had an established framework and on the other hand it developed into a conversation, being more accurate and providing more valuable information. The interviewees provided the necessary information and also the graphics and frameworks to understand concepts better. Moreover just to understand the studied information, the questions of the interviews are provided in the Appendix 2.

2.4. Analysis

Once interviews were made, the gathering of information was covered, so the next step was a correct analyze to be able to conclude if the hypotheses were right or wrong. The analyze method keeps the comprehensible form to analyze by Hammersley and Atkinson (2007) [5]. Categorizing responses in themes made the analysis easier, by trying to reason the evidenced correlation between several variables and to get a conclusion. A convincing line of reasoning has to be used to demonstrate any hypotheses; therefore, these hypotheses had to be drawn up before the collection and analysis of data.

The model of interpretation was the comparison between the companies models and DFSS suggestion [2]. It was interesting to identify how the chosen things differ, by presenting descriptive information about the two strategies. When the first analysis was done, some doubts appeared. Thereafter, recollection of data and questions to the company, which did not emerge during the phase of collection of data, were realized.

From the case study and reasoning of both companies about the strategies, the discussion was initialized, by giving an argued opinion about the different aspects of the processes and strategies. These opinions had to be oriented to shed light on the final conclusions of both initial hypotheses.

2.5. Validation and Reliability

The purpose of this case study is to know the possibility or drawbacks of implementing DFSS and advantages or disadvantages of this implementation; it is not to substantiate a preconceived position because we do not have any prior information. So as to ensure the truthfulness of the conclusions during the study, the internal and external validity and reliability had to be addressed, which is a challenging task. The construct validity is in charge of establishing the measure to test the studied concepts using multiple sources of evidence [2]. The data collection has to be accompanied with references, notes or descriptive documents that represent an attempt to integrate the evidence and convergence on the facts, because it could be useful if someone wants to inspect the raw data that led to the case study’s conclusion. The collected material was validated by sending documented material from interviews back to respondents for approval.

Once the data collection was realized correctly and the data were coherent and readily comprehensible, data were analyzed. The analysis should be a clear cross-referencing to methodological procedures of analyzing and to final results. In this phase, logic models and explanation building that could conclude the initial hypotheses of the study were used. Any interference needs to be proven with other sources of information; it must be based on convergent evidence or common sense.

The generalization in this case will not be possible, because the study will be focused on two companies, so a general conclusion cannot be extended; the external validity is more complicated. However, a qualitative reasoning with patterns of causal factors that were responsible for the results could be useful for future studies. It could be interesting to complement it with other case studies in order to reach a general conclusion. The achieved conclusion could shed light on some phenomenon of interest.

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2.6. Outcomes

The Master Thesis is expected to give the following results:

- An available, coherent and comprehensible document to everyone, trying to complete and shed light on DFSS area within real examples.
- Answer to initial hypotheses:
  - H1: there is no need for a uniformed Product Development (PD) process model
  - H2: The Core roles of DFSS are unrealistic to implement in the real world
- Clear opinion about DFSS
3. QUALITY

Quality [6] has evolved as a new concept from the idea of production, by dividing complex activities into easier tasks and separating the control from the production. This concept has always been linked to processes, goods and services. It emerged as an attempt to make perfect products in production, and evolved to reduce the time periods to launch the product to the market, to reduce costs and to be more competitive in the market. These objectives were not contradictory but they were difficult to reach at once; and priorities changed from the Industrial Revolution (higher productivity) to the Information Age (higher customers’ satisfaction). Up to 1950, the quality control corrected failures; it did not drive to prevent them. Then, the customer started to demand more quality and companies started to implement Continuous Improvement [7], through incremental improvements over time and improvement in different aspects within the company at once. Therefore, the management of quality has changed in the last decades.

Nowadays, quality is a multidimensional concept, and the major task of companies is to find out which dimensions are important to the customer. Quality is defined by many managers as: the concept that ensures customers’ satisfaction and overcomes expectations (Quality Manager, Company B). These dimensions cover: transcendental dimension, manufacturing-based, product-based, user-based, value-based and strategic dimensions; and all dimensions are interconnected [6]. A quality definition continuum links these definitions in order to create a line from internal perspective to external perspective (customers); so internal choices within the company lead to customer’s satisfaction [8]. The most committed companies are implementing a management in quality that involves the whole project and all the departments, for instance Total Quality Management. Total Quality Management is the management’s way to ascertain customer’s needs, through quality of internal process as well as the engagement of everyone in the organization [8], [9], [10]. TQM focuses on continuous improvement and quality definition continuum [8]. The figure 4 presents the wide range that is covered by TQM, therefore the big complexity to manage it.

![Diagram](image)

Fig.4. the interaction of Business Activities at Velden Engineering [10] Total Quality Management

The factors of Total Quality Management build the capability to innovate [11]. TQM looks for customer’s requirements; even for innovative ideas. It also involves a better knowledge of know-how, knowledge flow and motivation to do a better work and empowerment, by identifying specific problems that induce to novelty and lead to innovation capability in the firms. Therefore, quality could be a forerunner of the accumulation of innovation
within the company [12]. The Quality Gate is really a good example of management in order to relate Innovation Management with Quality Management, providing the required control by planning for innovation and implementing it during the lifecycle of the product. Consequently, quality and innovation are related thanks to the product development process, in order to achieve an outcome that customers are willing to buy and consume.

Quality is becoming a complete satisfaction: within the company (internal perspective) and for customers (external perspective). It creates a high competitiveness in the market.

### 3.1. Quality in Product Development

A major task, within the context of quality, is developing new products/services with a high level of quality. The process can be controlled with top-down and bottom-up strategies from the beginning [13], [14]. To get products with quality it is necessary to include this quality control in the product development process. Customers’ needs and requirements become the base line, and the quality control’s role is to translate correctly customers’ requirements into materialized products, through quality characteristics (QCs), during the product development process [14]. Sometimes, the concept of quality could be difficult to understand due to its abstract aspect, so several quality characteristics enable to break down quality into easier features to reach them, the figure 5 is an example of this problem to figure out the abstract concept.

![Diagram: Objective Quality vs Subjective Quality](image)

**Fig.5.** The processing psychology which might explain the different relationship between objective (independent of the existence of man) and subjective quality (what we think, feel) is currently not addresses, it is basically left as a black box. The Kano questionnaire enables measurement of the output from such processing but provides little support for a proactive strategy [15].

In recent years, Support Quality Controls are starting to be used in management of quality, by decomposing, transforming, optimizing, evaluating and monitoring QCs in product development, by emphasizing product characteristics’ definition, quality evaluation and optimization; not by just avoiding failures during the process [14]. In this control, the cross-team’s roles, evaluation system, problem-solving, shared knowledge and information within the organization are essential. The quality control is supported by quality tools that complement each other in order to cover the whole process [14].

Continuous Improvement methodology [16] covers a deep understanding of customer’s needs but its main objective is to improve products and processes over time. The deeper understanding is supported by the theory of the attractive quality [15], which consists of identifying attractive quality elements for customers. The theory of the attractive quality is being implemented on product development to innovate, to gain competitiveness and product commitment. However, there is a lack of defined concepts of attractive quality elements and responses.
Therefore, novel methodologies such as DFSS that drives quality measurement and predictability improvements in early design phases, could be useful for this theory and consequently successful, by going beyond consumer expectations and discovering these attractive quality elements.

Consequently, the quality could be dealt with from the two following perspectives: a continuous improvement and a new tendency of methodologies that intensify the role of customer. This master thesis will focus on these new product development processes, especially on Design for Six Sigma, which are more oriented and focused on customers’ insight, without underestimating the continuous improvement.
4. PRODUCT DEVELOPMENT

Product development is the process of transforming companies’ opportunities into real products [17]. Products have always emerged from a transformation. However, the novelty is the use of product development that takes the products and makes them more efficient, useful and attractive to customers. A process with quality ensures a better satisfaction of customers and therefore products with high level of quality [19].

Currently, surviving within the market and getting high quality are challenging tasks. Companies need to reach the future and develop new products that will enable them both to compete over the coming years and to reach high levels of quality [17]. This challenging task involves new products and the ability to carry out processes to get these outcomes [18]. Due to the current context projects should become better, more flexible and faster to launch the product to the market; some of these improvements are objectives of new product development processes, such as KES [20] or DFSS. Theoretically, supporting oneself without any significant development is possible, but these cases are exceptions [17] and the competitiveness depends on efforts to innovate and develop, among other activities.

Reality -as well as customers- has contributed to improve the product development in order to create successful outcomes that add benefits and revitalize the company. The success of a new product is achieved by relating upstream activities with downstream activities during the plan of action, with cross-functional interaction. It is closely related to team-oriented environment that facilitates the communication, information exchange and decision making [21]. Despite this there are several models to carry out the product development besides cross-functional processes. The remaining models are based, like cross-functional process, on linear models; but they deal with the feedback loops, the current engineering, the accumulation of knowledge and making choices differently [17].

There are different perspectives to deal with Product Development; the lack of only one approach could create misunderstanding about customers’ needs. However, variant perspectives could complete them and create a better overview of product development [17]. Therefore, these processes are dynamic. Processes have a certain grade of risk in new products development.

Product development is often divided into several phases: discovery phase, development phase and commercialization. The classification varies depending on the company. During the discovery phase the product’s definition and requirements are developed, products are tested, requirements are collected and analyzed, and market opportunities are identified -technical and non-technical issues-. Everything is designed to improve efficiency, increase sales and reduce costs. Requirements and specifications are translated into products and they are kept up under testing in the development phase. Finally, products are launched into the market. That is, the main product development’s functions are: product research, industrial styling and coordinated planning [19], [22], and these are part of the chosen strategy by the company. The figure 6 brings to reader view an example of a roadmap of a process. These stages are supported by a set of tools.
4.1. Product Development as strategy

The strategy is the pattern to achieve the wished goals and objectives of the company; it involves a plan of action that should be followed. The plan of action evolves stages that are frequently subject to change: corporate planning, marketing planning or technology management. Product development could be considered as a strategy, which provides an opportunity for remaining on the market and getting a larger growth than competitors [17]. This strategy diverges depending on the focal point (new products’ features, new technologies) and the change’s scope; the table 1 provides the different strategies to innovate.

Product development is an interesting strategy because the customers are not the only people who are satisfied. In fact, it has been shown that as a consequence of using this strategy companies find new methods and processes, discover new uses for wasting and saleable products, develop new products, reduce costs, enhance their sale’s ability and enthusiasm [17].
4.2. Product development and customer’s satisfaction

Product development takes the products and makes them intimately related to customers’ needs. A strong market orientation is necessary for the success of new products and to ensure a certain level of quality. In order to take in consideration the customer experience, some concepts such as creativity and innovation are useful; these concepts are emphasized to complete customer satisfaction. To many people, new products are the outputs of the innovation process, where the new product development process is a sub process of innovation [17].

However, the innovativeness of the product is associated with customer utility and uncertainty; and one task of managers, who are responsible for introducing new products, is to control the negative effects that arise from customer uncertainty [23]. Therefore, there should be a balance between uncertainty and customer utility. Furthermore, the organization cannot pay attention only to current requirements of customers because it is not the competitive key of advantage. The company should articulate and ask themselves for more advanced needs. The sharing and management of knowledge work as a boost to innovate. However, it also emerges within a quality framework. Innovation and quality could be contradictories, because an organization with a strategy which is focused on innovation does not have enough time to learn and study the processes in order to accumulate knowledge about the process. Therefore, reaching a high degree of quality is difficult and a challenging task. The optimal choice is to achieve a balance.

Theoretical basis has not been found on how innovation supports quality and how it contributes to an organizational performance quality, but they are linked [12]. Innovation quality depends on how well a company is following innovation in the product or services, through variables as effectiveness, complexity, innovation degree,
value to the customer, cost, among others. This definition is completely different from quality innovation that is related to a particular form of product innovation within existing boundaries. Innovation quality could be related to innovation management system of one organization through these variables and its assessment could be used to measure the degree of innovation quality of the company [12]. Patterns of innovation quality provide awareness regarding the innovation activity within organizations. Companies are able to align strategy and innovation quality, understanding customers as a result.

In conclusion, customer orientation, creativity and innovation are important factors to influence the product development process; and they are closely interconnected to quality in this process.

### 4.3. Role change in product development

The necessary cross-functional process is associated with the team-oriented concept; team-players who can communicate in problem-solving and decision-making stages during the product development process. Beyond being good communicators and team players, they have the opportunity to influence on the product development process. Therefore, they must have specific skills. These skills should help resolve conflicts and give experience to face new set of responsibilities and unknown concepts. Team-players should have the ability to understand and clarify the project targets. They will be responsible for the accumulation and sharing of knowledge. Members will enhance the company’s knowledge base, integrating different expertise areas [22]. Actually, their task is to contribute to create high customer value and support the product development process.

Thereupon, product development is a complex process and it involves several aspects that will be explained below, such as: customer orientation, innovation-creativity and the organization related to product development and quality. The choice of following a product development process in a company forces to proclaim a certain standing in these areas, to understand the task and be coherent so as to be successful. In order to define these standings DFSS was defined by the supervisor of this master thesis as the suggested product development process. DFSS is a novel methodology to manage product development processes within a quality’s framework; it is less standardized than others because of its novelty and lack of real and completed implementations. It derives from customers’ expectations.
5. DESIGN FOR SIX SIGMA

All companies are involved in a competitive world, where quality can be the difference between companies. They can take advantage of these differences in order to be the customer’s choice. DFSS offers an opportunity to be the customers’ choice.

Previously, one recognized model in quality control was PDCA (plan-do-check-act) [24]. This was a good precedent which is nowadays noteworthy to consider next quality methodologies in product development. In the 1980s, Six Sigma [24] appeared as an attempt to improve some aspects of products and services, that is to say to reduce its failures as much as possible during the production phase. However, there was still a lack of customer perspective over the project. Nowadays, DFSS is changing the ambition level of Six Sigma, because it tries to develop the process in order to satisfy the customer’s expectations, within limits, consistently and reducing performance variation/ the failures. Six Sigma focus on the final product and DFSS focus on the process, it is a process improvement. The core of this methodology was from the beginning to approach product development to customer needs. Harry and Schroeder in 2000, planned to create methodologies of DFSS that were resource efficient, able to reach different fields independently of complexity and volume, robust to variability and closely related to customers’ needs [25],[26],[27].

5.1. Concept of DFSS

Design for Six Sigma is a concept to improve and organize the development process and its activities. It supports the importance of a modeled process although there are difficulties to find out and implement it. The development of DFSS is based on tools and techniques, roles and processes. It could be used as a driver in a project or implemented in PDP to adapt to different projects [28]. DFSS pretend to be appropriated to take processes beyond its design capabilities and to turn innovative ideas into customized and marketable products [29].

Quality, as an umbrella, is very difficult to measure; so a breakdown into simpler activities with different tools can be useful. Many companies are aware of the type of isolated tools and the problem arises when an oriented method that employs different tools in the same project is needed [30]. In order to avoid bad reactions due to poor quality, the customer needs not to be borne in mind only at the initial or the end point. The initial point can change or be left aside and the end point can be too late and expensive to redirect. The base line of DFSS is a big amount of different tools and techniques which support the process and help them to be more efficient and effective; not only with surveys at the beginning of the process but also with tools and techniques during the evolution of the project which are especially related to customer needs. Therefore, the structure allows analyzing thoroughly and breaking down it in easier and simpler activities. The structure makes design quality’s predictions easier. Although DFSS covers the whole process clearly, there is not an agreement on the exact starting point and end point. From a certain point of view DFSS drives the customer orientation, so it could be reasonable to include the idea generation phase through tools that provide and collect ideas from customers. But there are other theories which support the idea generation phase as inputs of these processes [29]. The same problem arises when the product development stage finishes and the production order is given. However, in order to obtain a successful product there should be a continuous communication between departments. One of DFSS’s objectives is a continuous improvement that could itself become a reason to reach the product’s launch stage and control the ongoing operations through DFSS. The figure 7 shows two examples of DFSS from two different points of view, by covering different stages of the process.
5.2. Roadmap for DFSS

DFSS emerged thanks to consultants who wanted to differentiate their methodologies from others so there is a large amount of usable roadmaps (i.e.: DCOV, DMADIC, DCCDI, DDOV, DMADV, DMADOV, DMEDI, ICOV) [18]; this variety of usable models is problematic during the implementation phase; it is an undefined way to define the process. The major part of the existing literature sources deals with it. It is authored by those consultants who wanted to earn money and convince with their reasoning [24], while actually there are not real examples and techniques of implementation. Each one of the phases of these roadmaps are supported by a set of tools that cooperate and the novelty provided by DFSS is the use of tools that are prepared to achieve a right customer insight. Below, one of the roadmaps described.

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Table.2 Roadmap for DFSS (IDOV) [31]
5.3. Organizations in DFSS

Furthermore, DFSS uses a role structure that ensures a cross-functional group and it is common in Six Sigma; the division between Black Belt, Green Belt and a Sponsor DFSS [18], [20], [23]. They must undergo training and in order to reach these roles they need some minimum requirements and skills. A cross-functional structure is a requirement in this methodology.

5.4. Outcome: DFSS

To clarify the concept of DFSS, the activities and tasks it involves could be summarized [24]:
- Drives the customer-oriented design process with Six-Sigma capability
- Predicts design quality at the outset;
- Matches top-down requirements flow down with capability flow up;
- Integrates cross-functional design involvement;
- Drives quality measurement and predictability improvements in early design phases;
- Uses process capabilities in making final decisions;
- Monitors process variances to verify that customer requirements are met.

DFSS is becoming quite popular among companies [24]. However, good examples describing how DFSS works and is being implemented in companies are still missing. Nowadays, DFSS can be seen as an opportunity to change the process in a competitive world, by ensuring robust and continuous improvements during the processes. However, the advantages or disadvantages are still unknown. The question is if the methodology will actually be so useful and effective as the theory explains. For this reason, in order to evaluate DFSS’s involvement, the customer’s satisfaction, the innovation, and roles’ structure are necessary; and they are studied just below.
6. CUSTOMER´S SATISFACTION

In order to get a right customer insight, the company has to try to understand its target market and control it during the life of the product. Being human has the ability to think, to develop within certain environments, and the tendency is to get a well-being level. Society is not conformist, once a level is reached then the aspiration is the next level. People carry out their lives in order to be happier and more comfortable so aspirations and ambitions are increasingly higher. It is a challenging task for the company because the current portfolio is not enough. It is the starting point of a competitive world.

Individuals search the fulfillment of their needs in two fields: individual and social utility because they are living in a shared context [32]. Due to the range of the needs and expectations, together with the broad overview of personalities, there are too many perspectives to cover so it is a difficult task. There are a lot of theories, some of the proposed theories are overlapping and some others are conflicting [32], [33], [34]. According to Veenhoven (2008), happiness has two components: the feeling experienced with the fulfillment of needs and the feeling experienced due to the difference between what one wants and what one has. This difference becomes more important depending on the social standards because society influences people’s wishes and expectations. Each customer is an individual that has to be understood in his/her atmosphere: social, psychological and physiological.

Utility function is a human welfare representation through a mathematic expression. It measures how the person is enjoying by consuming certain goods. It is not an absolute number; it sets up as a consequence of comparisons and preferences. Customers give value and priority to something because it creates more satisfaction than any other goods. Priorities vary between customers and depend on the context and available resources. In addition to needs, during life there are several temptations which are more difficult to measure and control. Temptations could be defined as desires which conflict with initial preferences [32]. These special desires change the possible order of importance of needs for everyone. Therefore, the behavior of human being is not so easy to predict; it is a mixing of spontaneity and precautionary measures.

6.1. Management of customers´ knowledge

The quality of a product is its ability to satisfy human’s needs, so the company should try to develop products that achieve these needs. However, these requirements have to be translated because the manufacturing personnel are not instructed on how to satisfy consumers’ expectations. It is necessary to translate quality into concrete and tangible concepts, through quality features [36]; these features are named requirements and they are included in the product specifications. The prior sections explained welfare by relating it to how a good society feels in its daily life. Some authors relate well-being to consumption, consumer surplus or propensity to consume. It is impossible to fix every requirement; but some factors are important such as: customer needs and wishes, safety regulations or capability of processes. Any failure may have unexpected consequences. Therefore, some of the requirements are continuously checked during the process.

New product development is an intensive process, and knowledge management is absolutely necessary in fields such as: customers, market (competitors), the own organization, resource constraints, and availability of technologies. Data acquisition, is as important as interpretation of this customer information. Knowledge management could enable companies to save costs and to increment revenues and capital within the organization by getting a fast time to the market, better customer service and creating innovation. Product, customer and innovation management could have a direct influence on the increment of the value of products and services. Therefore, most of the companies are making efforts on knowledge management [37], [38], [39]. Success depends on the effectiveness to generate and apply the knowledge management in new products. Knowledge management is an iterative cycle [37], it consists of translating the tacit knowledge that is difficult to identify, capture and
control, into comprehensible forms to develop a successful product. If the customer and product knowledge are managed at the same time some external risks are prevented because the user’s requirements are achieved and there will not be rejections.

In order to keep a good knowledge management, it should cover three dimensions: knowledge for customers, about customers and from customers [38]. Knowledge about customer includes customers´ background; from customer includes the pattern of consumption of final users; and knowledge for customer includes the satisfied needs of customers. All these dimensions are useful to create a competitive product. The customer knowledge is focused on extracted information from database, while product knowledge focus on realization and generation of the information. Therefore, these three flows of knowledge are essential.

6.2. Approach to the customer during the product´s life cycle

This section is an example of monitoring the customer insight during the life cycle of the product. It is interesting because it shows the importance of this monitoring during all the stages of the process, even after launching. Some tools are also named and recommended.

6.2.1. Human needs to design elements

There are several theories that show the relationship between the consumer and the product in distinct ways. Desmet and Hekkert considered emotions as the most important affective response to experiences with products. They distinguish these affective responses by dealing with the product as an event, an agent or an object; it is the Model of Product Emotions [33]. On the other hand, Norma dealt with emotions and products experiences from three levels: visceral, behavioral and reflective levels [33]. Other researches focus the importance on functionality, usability or pleasure when the product is being used by customers. Due to these relationships the customization is necessary and especially on mass-customization companies that are studied in this master thesis. Kano’s model identified the relationship between the fulfillment of the consumer emotions and design elements, and he showed that the relationship is not linear. He classified the needs into: basic attributes, exciter attributes and linear attributes; depending on the type of induced response in the customers [17], [39]. It is shown through the figure 8. This differentiation provides different weights to different attributes because they do not influence in the same way. Companies have to look for the sweet point, the attribute that could distinguish them from competitors and consequently becoming the choice of customers.
There are several techniques for translating consumers’ subjective impressions into design elements about a product. Kansei Engineering is a product development methodology to identify the needs of customers (expressed in their own words instead of words of experts) and try to relate them to design features. [38], [39]. In the late 1960, Quality Function Deployment appeared as a group of tools that relates requirements of customers and engineering characteristics; and also point out most important characteristics of customers [40]. Costumer experience (CE) is another methodology that describes affective needs through extracted keywords in surveys. It was designed to support mass customization companies [38]. All these tools are useful to apply in any Design for Six Sigma process, to introduce and translate the needs of products end-users.

6.2.2. Pattern of Consumption

Once the knowledge flow is working the company is able to cluster the customers by basing on common needs and patterns. It is able to segment the customers because they manage accessible information. For instance, the company could use programs as Data Mining (DM) to extract a pattern and to get hidden information from database [38], [40]. The opportunity to segment provides defined features for each group. Connecting needs with requirements of products and satisfying customers are easier tasks when the market segments are already done. Companies could choose which the best target market segment is according to their portfolio and which activities and strategy will be better to launch the product.

6.2.3. Customers’ feedback

Once the product is launched to the market the product’s process is not finished; the task of the organization is to receive a feedback about the product purchase and consumption; it overcomes the process of product development. During the product development process is interesting to know which will be the market’s reaction to the product, the purchasing intention, the interested segment on a certain good, patterns of consumption and perceived satisfaction.

Fig.8. Kano Model [17]
improvements. It is a help to retain customers from the PDP. These activities to retain the customer could also take place during the project’s progress, not just prior to start it or after the PDP. The feedback contains values perceived by customers about features, uses and functions. The feedback allows the company to revise the product, reconfiguration of requirements and therefore to restart the process of product development. The reconfiguration makes customer rapprochement easier and faster. Furthermore, feedbacks could provide more information to complete the customer’s database and to check the reliability of the patterns on this database.

The continuous feedback is a channel for greater efficiency through improved relationship between several fields of the project and a chance to increase profitability. The effective implementation of customer orientation needs this feedback in order to complete the awareness of customer service in the whole organization and all the operations [41]. Within the company, the organization should consider the way to run the mission as a way to get customers’ satisfaction by involving the customer in the core strategy and adapting the strategy to these feedbacks. But the real problem is to implement the mission in real life; to ensure the loyalty and maintenance of customers or their participation during the process. The next graph, figure 9, is the case of 3M and demonstrates the different responsibilities and activities to manage the customer insight during the whole process.

![Architecture of the recommender system](image)

**Fig.9** Architecture of the recommender system [42], i.e. Importance of role structure. DB: Data Base, DM: Data Mining

In new product development there is a confused feedback because the customer does not really know to articulate their needs and there is not an existing market so the problem of how to deal with these customers arises. One solution to this problem should be to learn and to make the customer participants of product development processes by showing every modification in products and the explanation of these changes. The choice of forgetting market orientation will not make the company competitive. At the beginning changes and innovation can not be understood and rejected by customers but the suitable learning could help to accept new variations. In spite of recommendations to markets and an innovative orientation the new products are also developed from a technological perspective [21]. Thus, there is a big amount of information from different fields to manage and there is usually only one group within the organization that can work with it. In many occasions the help of IT system has proven very useful.
7. INNOVATION

Lately, when the consumer perception has become more relevant and there is an increasing interest in the effective and efficient process in the market, the concept of innovation is getting importance. There is nothing written about neither the amount, degree of innovation nor the nature of innovation itself. In addition, several definitions of innovation have been provided. Therefore, a number of distinctive features have to be managed [11],[12]. Innovation can be considered as a strategic resource to approach customers’ needs. Quality is no longer a big differential element so the customer experience can help in this function [43].

From a market orientation’s perspective, inventions are the outcomes of processes which are perceived with a certain degree of novelty, increasing utility or capabilities, by including new resources, processes to supply, distribute and manage, new market opportunities, different organizations’ work, even differences in working conditions and skills. This newness involves a higher value to the customer, which is considered as innovation. Moreover, creativity is the ability and capability to think about new ideas to develop the innovation process. Knowledge, capability, resources and supportive structure and control are required to facilitate the process and to bridge the gap between invention and innovation; inventions can be conceptualized practically anywhere, while innovations require a more supportive structure [44].

Innovation can be radical or progressive in the product (product, processes, marketing or organizations) and it has some positive effects, in addition to competitive advantages, such as a higher growth of the company, the creation of new jobs, a wider product portfolio/ an opportunity of differentiation, a revitalized demand, lower costs, obtaining better satisfaction of customers and an increase of productivity. Furthermore, the innovation entails a batch of disadvantages and constraints that will be analyzed below.

7.1. Constraints to innovate

Managing innovation involves developing creative potential, fostering new ideas and generating creativity but at the same time it also implies a level of uncertainty about the ends (what are the targets of the project or activity) and the means (how to achieve these targets) [17]. A dilemma emerges due to the stress between the needs for stability in order to accomplish the tasks in an efficient way and the need for a dynamic environment where the ideas can be developed and tested (Dilemma of Innovation Management) [17]. Innovation is an abstract concept and consequently the implementation in processes is quite hard. There are several paradoxes that make understanding difficult, for instance, it needs certain freedom and pressure environment [45]. The pressure is a lock element and it could be seen as contradictory to freedom; but the key to success is to get a tradeoff between compulsory assets within a flexible context. An innovative organization works in an unpredictable and variable framework, but the definition of organization is like a structure which works based on routines, engineering logics and predictability [46].

There are two trends of thought about what delimitations of innovative activity are within the market, the market-based view focuses on the idea that market conditions provide constraints to development; in the other hand, the resource-based view focuses on the firm and its resources, capabilities and skills as delimitations [17], [46]. Activities of innovation could emerge thanks to serendipity or following a model (linear or interactive). Both of them create something, but many of these companies believe that creative thinking cannot be reinforced. The solution is just to wait for serendipity. Nowadays, it is shown that certain behaviors can help to enhance creativity in a world of interminable opportunities. These could be deliberate ways such as lateral thinking, interdisciplinary practice, teamwork, rewards for productive thinking and creative problem solving [47]. Therefore, creative thinking strategies must become part of organizations.
7.2. Innovation - knowledge

In the market, the ability to be competitive will depend on new ways to face changes, to manage the knowledge and to grow on expertise training [48]. In order to be an innovative company, basic competences must be studied. Basic competences are its intentions (mission and vision), the own knowledge and the capability to reach the wished objectives. The capability is influenced by the ability to be creative, available resources and the talent of the organization [48]. Although innovation emerges from a creative environment and it is part of its capability, the capital creation and problem solving potential are an intermediate level that derives from creativity [49], [50]. The capital is the knowledge of the organization and it works like a boost element of creativity in the iterative cycle of innovation. This capital is suitable to be used, stored, to control and to create in different ways, it is a strategic asset for the company. This way of controlling capital could differ among companies and they should take advantage of it, because just the knowledge does not differentiate them since it is approachable by everyone thanks to new communication and information technologies.

Because knowledge is a springboard for innovation, during the innovation process, the organization should try to control this capital and raise its productivity [48], [49]. Therefore, it could become another functional activity within the company that encourages new circumstances to create knowledge. In addition, the accessible information is increasing. Therefore, a management of it could make problems and decision making analysis easier by using the most appropriate knowledge. This knowledge has three overlapped dimensions: structural capital, human capital and relational capital [50], [52]. These three dimensions must be aligned in order to fix the capabilities of the organization in relation to the environment, by creating opportunities to develop new knowledge from individuals as well as from the whole organization. There should be an alignment between knowledge from individuals, the whole organization and the knowledge created jointly.

The management also involves the control of human resources; they are the owner of knowledge. To hire and provide several responsibilities to different human beings is a challenge. These structures consist of divergent routines, experiences and relationships that can be a spring of new points of view. The management should deal with chaos and order, and it should be also closely related to the creation of a creative society.

A major element of this management is the spreading of knowledge through collaboration between entities, because the knowledge can be created in any stage or activity (learning-by-doing or learning by using [51]) not just in research centers. The company is able to take advantage from these collaborations because they have access to new knowledge, opportunities, expertise and supports on complementary fields and solutions to their problems [48]. This function is not always so easy due to the different objectives or motivations, available times, styles of management and confidentiality of the organizations. The formation of teams, associations and learning societies facilitate the sharing of deeper knowledge bringing together diverse talents and cultures with different points of view. It could be similar to the Wikipedia network, capital instead of definitions, Wikicapital [48].
The figure 10 tries to explain that the business opportunity is boosted thanks to the managing of the customer’s knowledge and the generation of product knowledge. It provides new opportunities to produce and understand the customer.

7.3. Innovation- creativity

A successful knowledge management stimulates creativity and faces fast changes, by bearing in mind new frameworks where products will be able to develop. The achievable scope of innovations is established by the talents of the creative individuals, their scope as an organization, and the provided capability thanks to technical resources. Hence, creativity should be covered by these three perspectives: individual perspective, technical perspective and organizational perspective, which are interrelated [45].

The creative capability, from the individual perspective, depends on cognitive ability and personality characteristics [45]. The cognitive abilities emerge from the personal intelligence, the thinking style and the background knowledge. The background knowledge is not just about relevant areas; it is also related to complementary areas because they have a different point of view, other thinking styles. For instance, Kepler was a mathematic and he postulated its laws about astronomy. Moreover, the appropriate personality will reach a high level of creativity, which is a faculty to risk taking against the standard behaviors. An independency to feel free, self-confident, curious and motivated to face the complexity of problems and being perseverant are essential features of the personality [45], [50]. These features facilitate the process and they are part of people’s values and culture, whilst the cognitive ability can be improved with training. Any emotional feeling could influence the creative environment, for this reason the company usually invests on human capital, to keep it and not to disturb it.
The technical perspective supports and provides tools to develop the capability of individuals to reach creativity. Technical resources are formed by human and material resources. The organizational perspective is closely related to the individual perspective because the individuals create the group but at the same time the group provides the environment where they work. The organization encourages and empowers the individuals to act creatively; for this reason, they are responsible for reaching a flexible, openly, free, risk-taking. This is a challenging work environment.

The managerial role in creativity is not an easy role, because the qualities of a typical organizational member are not enough to achieve success. They have to work with some paradox, risks and unpredictable answers, ideas and events [55].

7.4. Innovation process

In order to implement an innovation, a series of stages are required as in any other process. By definition a process requires time, resources, capabilities, knowledge, structure and control to ensure the wished output. Many authors support the idea that the products are the eventual outputs from the inventions and that process, from new discovery to eventual productions, is the innovation process [17]. The innovation process is led by internal and external drivers [48]. Internal drivers are carried out by activities within the company and they depend on the capabilities of the organization; and external drivers are associated to its own sector and its environment.

At the beginning, the innovation process was led by external technological innovation push, as a linear model. Towards the middle of the 1920s, the importance of R&D was growing and the innovative process started to change [48], [49]. For Schmookler, the demand became a pull factor to the innovation process; due to the process’s complexity, the model could not be linear any more [49]; the models needed integration and coordination of units and a close communication. Kline- Rosenberg suggested a complex model. It was not linear and was supported by feedbacks and pulled by the market [48]. The linear and and chain-linked models are shown by figure 11, and it is easy to realise the difference between both processes.
Innovation management is a series of activities that are linked in some way to the others to transform an initial energy from the idea generation phase in order to improve. A framework could exist, although this process does not imply a strict structure. Each of these activities of the innovation process, that create a network rather than lines, are involved in creative management. This process covers various functional areas and several disciplines so it is able to reach a higher dimension of creativity. They are merged thanks to the control of the three perspectives: individual, organizational and technical resources; during the whole process. The lack of hierarchy and formality supports innovation more effectively [17], [12]. From these processes questions emerge about how to integrate these new processes into the current product development processes of the companies, such as DFSS. Some companies are implementing innovation in their product development using Gates Quality. These gates provide the control necessary to deliver innovative output and risk management during the project execution. Quality Gates guide a collaborative team through lifecycle of an initiative of innovation [44]. There is not only one way to implement creativity in the product development. For instance, 3M created a Transfer Unit to act in the chaos of innovation, making the coordination of ideas, information, commercialization and control of activities easier. They perceived the transfer unit as a business opportunity to cover activities that are difficult to approach from other roles in new product development [49].

There should be an environment more prone to creativity within organizations because the capabilities and attempts to innovate are not enough. Several characteristics facilitate the innovation process such as: free communication, authority for taking decisions based on the expertise of the individual, allowing free adaptation to changing circumstances, creating emphasis on norms of cooperation, having decision making consensus frequently, growth orientation, commitment to technology, acceptance of risks and receptivity to changes [17].
In order to have a successful long-term improvement product development, organizations combine their own product development process with other approaches that are better suited to make progress on innovations [29]. For instance, the DMAIC structure is supported by creative thinking about the problems and its solutions within the definition of the original product, process or service. The combination will be close to success because the use of methods with hierarchies moves away from creative thinking (Dilemma of Innovation Management).

In conclusion, within the innovation context, due to the need of management of creativity, knowledge and market information, human and technological resources and the own product development process, the techniques does not have to be dealt in isolation. The only one way to study is through a mix of tools and methodologies, so the whole potential of the organization will be exploited. To implement an innovation management involves time, effort, motivation and money. Actually, the innovation management is a theoretical and abstract concept and it could originate a lack of motivation and knowledge about the real application.
8. ROLE STRUCTURE

Product development provides opportunities to take advantage over competitors. It transforms intangible ideas into real products, by working in parallel with downstream and upstream activities during the process, in order to get an oriented product to the customer. Roles structure makes the flow of information easier when making decisions and it joins efforts to reach the goals of the organization in spite of the different objectives of the departments. An understanding of the market will be necessary to get a successful product development. Due to the fact that product development is a combination of upstream and downstream activities, it could be seen as a multi-disciplinary activity in which there is a continuous interaction between people from different functional departments and different levels of hierarchy within the company [54], figure 12.

![Fig.12. i.e. cross functional team](image)

The process works in a creative and free environment, but many variables have to be managed and controlled by trained people. Once the first idea about the future product is launched, control becomes difficult; there exist the risks of moving away from customers. The uncertainty and costs are high. Many times during the process of product development, there is an inadequate management of the project involving a lack of commitment, unclear roles and responsibilities [55]. This environment is forced to fast changes in roles and responsibilities and the employees have to know how to face these challenges.

8.1. Training

The management of the product development process has to let every employee know that the approach to the customer and quality is part of their responsibility. They must be willing to train and to learn. They have to be motivated to become knowledgeable about the subject [25]. Training is a major part in becoming a successful manager or worker in product development. However, they cannot forget the long run of their activities and include needed skills beyond technical and statistical tools, which will help to achieve success. These skills are: leadership, team-building ability, being a good communicator, coaching and mentoring [21], [56].

The career of these workers is completed thanks to prior education and on-the-job training -theoretical training together with informal training, which depends on the knowledge of upper levels employees/staff and trainers [56]. Prior education comes from different positions because for instance, there is not a straight path in the industry to reach the sponsor´s role. Therefore, during the on- the-job training process, these people have the opportunity to
learn the appropriate skill levels and knowledge. Both educational ways complement each other, because practice does not make them perfect; managers have to be ready to act fast in order to prevent problems anticipating them. Prior education and on-the-job training are both necessary.

Although training is useful, the requirements of new managers should be assessed when they get the new position, and the training should be oriented depending on the field and new position. In fact, these roles vary between companies because they support different approaches to product development and their main factor in PDP differ (Six Sigma, DFSS, Lean Product Development). This training should allow certain freedom and should not set aside creative efforts that are essential in product development.

In short, it means that these roles and their training are really important since they are in charge of developing product plans, ensuring their delivery, monitoring results, taking corrective actions, detailing design, testing and refinement actions, without restricting creativity [21], [56]. Project development projects have to become better, flexible and faster [18].

This changing environment around companies forces them to rethink and readjust the organizations, its hierarchy and the relationships between workers. It involves a new arrangement of tasks and people, by breaking the old tradition of bureaucratic levels within the company because the talents can be at any level of hierarchy and it entails new relationships. The new tradition is closely coordinated and integrated teams and project group. These project groups will face problems from a horizontal coordination [56].

Thus, many companies support these role structure in their product development departments, horizontal rather than vertical relationships. Therefore, a cross-functional team from different levels of management and functional departments is necessary. Besides the cross-functional team, there are major roles that are in charge of the implement methodology to carry out the process of product development. The classification and names of major roles varies from different points of view: CEO, Sponsor, Black Belt (Master Black Belt), Black Belt, Green belt, project leader and process owner [59]. The suitable people for these roles could have different backgrounds (engineering, general management, quality and finance) and their selection is very important. A specific number of people for these roles does not exist, it will depend on the complexity of the project and on the size of the organization [58]. At the beginning, the technical background was a major factor to be accepted by a program that was dedicated to quality, although they also had to demonstrate problem solving, project management and teamwork skills [58], [60]. They could make progress and reach the corporate executive body of the company.

An essential component of roles is the training of employees for these roles, which is improving, but still there is a gap of information about it in the different methodologies [59]. Learning should not be about all tools, just only about specific tools depending on the status of the person and the established duration of the process; because after all, their task will be a continuous analysis and measuring of processes to improve and control specific tasks. After training, some roles receive a required accreditation to practice management. There is no agreement on how to obtain accreditations; some acquire it thanks to exams (case of Motorola) or supporting letters from upper-managers (case of General Electric) [61]. Researchers agree that employees have to carry on several processes to get the status and they need to possess a basis about statistic tools [59].

The personality is a major factor for deciding which person is suitable for one specific role, because of this the choice is influenced by his/her behavior and skills. There is not a specific personality that will be better for one role or another, but some features will help to manage and control different phases of product development [28]. A way of measuring and knowing how people tend to behave and react in real situations is MBTI (Myers Briggs Test Indicator) [61]. In addition, it will be useful because employees will work within a cross-functional team and they will have to work cooperatively with different personalities. Thus, they should understand opposite behaviors.

8.2. Role structure in Design for Six Sigma

The structured organization of roles is a success factor of the methodology. Black Belt role structure from Six Sigma measures how well processes are working and the alignment between companies’ objectives and their
Design for Six Sigma goes beyond Six Sigma. Whilst Six Sigma is a methodology to improve all aspects of the company’s products and services in general, DFSS provides methods to approach customers and their needs with effective and successful product development processes, focus on process improvements. Some companies argue that there is only one way to become a DFSS role hierarchy, it is through Six Sigma training, the Black Belt Roles of Six Sigma. But actually Six Sigma and DFSS differ widely.

Focusing on Six Sigma’s training could be a problem, because the importance is to get skilled people and not to pressure on translating Six Sigma into DFSS. On the other hand, it is a perfect bottom line to build the role structure of DFSS. However, DFSS program suggests complementing this training with other tools such as: voice of customer, QFD and design experiments; even tools that could reinforce innovation management and lead it to create a project team. DFSS Black Belts should control not only statistical techniques but they should also understand the development process. Therefore, there is not only a particular background to success, their selection is based on their skills, and there is a trend to select them according to their quality backgrounds.

Finally, the conclusion is that the relation between Six Sigma roles and Design For Six Sigma roles is still not obvious. To be able to use DFSS, managers have to be trained and before that, organizations need to prepare a plan for a DFSS program.

9. PRODUCT DEVELOPMENT IN THE COMPANY A

The Company A is a mass production company in the household appliances field. It is also in charge of appliances for professionals. The Company A is a global leader, with more than 40 million products, including refrigerators, dishwashers, washing machines, cookers, air conditioners and small appliances. It is present in more than 150 markets, through innovative solutions and has a strong consumer insight. During the last year (2011), its sales achieved SEK 102 billion. The goal is to create a company for profitable growth, a global company; so a more efficient one with a reduction of the time to market.
The Company A emerged as the idea to provide customers the opportunity to get innovative products that could be sold worldwide; they should be achievable for everyone. Axel Wenner- Gren was the most enterprising salesman of this company, he led the company to success. It has come up today because of the merge of other companies; it is a decentralized company due to mergers and acquisitions. Nowadays, it has more than 58.000 employees, creating a strong brand [74].

The Company A develops the product development process starting from consumer needs. Right now they are implementing an upgraded process. The decentralized nature of the company had led in the years to various interpretations of the product development processes, thereby making communication more difficult and adding a high amount of tools. The upgraded Product Development Process in this company is based on consumer insights and on the cross-functional responsibility around the project where the clear task assignment and collaboration are essential pieces within the puzzle. In order to support this new approach, the Company A has created the Group Product Development Processes, a new department in charge of optimizing the product development process within the Company globally.

### 9.1. Interviewee

The interviewee is a process and project manager within the Group Product Development Processes. Its main goal is to get a globally aligned product development process by optimizing tools and sharing functional best practices available in the Group.

This person started her career in the Company A as Strategic Initiatives Team Leader, Technical Assistant and Modularization Process Manager.

While taking care of the process roll-out, her daily activity is also about evaluating areas of improvement in the newly introduced product development process mainly on the basis of input and feedback from the various functions active in product development projects worldwide. In addition, she makes sure in collaboration with the other team members within the same department that certain best practices in place locally can be adjusted to be shared globally. This is the way the full department drives the process excellence by continuous improvement.

### 9.2. Summary of interview content

Currently, the Company A is in the process of becoming more and more global, therefore its internal processes need to get adjusted to the new environment as well as to the need to further reduce time to market. The GPDP Department was set up in order to serve this purpose.

The new global set up requires that everybody speaks the same language also when it comes to developing new products. In addition certain shared product development principles will ensure more effective front-loading with a direct impact on reduction of time to market. Furthermore, taking the consumer needs into proper account and consistently translating them in product requirements and features in the early stages of product development also contributes to bringing to market consumer-relevant products faster.

The reviewing and upgrading of the product development process according to the above-mentioned principles took roughly one and a half years. Currently the upgraded process is being rolled out successfully as the number of positive feedback shows.

The upgraded process as the original one-works through checkpoints, i.e. scheduled meetings done to check if the commitments are being reached. Knowledge management principles have been introduced in order to be able to
capture learning from the project and utilize this knowledge in the future projects for the sake of continuous improvement. During the start phase, the project group receives a description of the opportunity and at the end stage they launch mass production.

The upgraded process also involves change management principles, throughout the complete process. Product development process teams are cross-functional where the project manager is one of the functions. Traditionally the project manager has been preferably from R&D background, but in the future this will no longer be the case.

The role of the project manager, who supports the project team, is indeed changing. This person has the responsibility to do the things really. He should have a deep understanding of the project from multiple perspectives to and make sure that the flow is properly working. The project management flow is controlled by tools as Gant charts, and they have a dedicated IT tool that to follow up on projects. The project organization is set up so as to allow the project manager to have functional representatives as direct spokespersons in order to make the communication flow more streamlined. The upgraded PD process is being rolled out also by means of training sessions that – among other things – focus on the importance of team collaboration and on discipline around who is expected to do what by when.

The Quality Plan is realized in each stage of the product development process. The Company A employees should know who does what and which deliverables are expected to be presented. It is based on reliability and performance. It overcomes ISO requirements, because ISO rules do not focus on product in detail, it is more about how to plan during a process. The following figure 1. shows the process assessment of Quality of this company.

Innovation is embedded in the whole process starting even before the project comes to product development stage. Opportunities for innovation are captured already during the portfolio planning phase that is also related to the strategy of the company; this is about where the Company A wants to go. They emphasize: << the main aspect is to detect the innovative idea soon enough and an organized knowledge management >>. Business intelligence data are aggregated to identify opportunities which get thoroughly assessed from many perspectives. Capturing innovation and bringing it to market in a profitable way is sometimes difficult in the white goods industry where in many cases control on costs is an important factor and competition is fierce.

In conclusion, the Company A wants to develop new products based on consumer insights through an improved product development process [72]. The question is to translate the needs of humans into features of the product. These features emerge from a business opportunity that is proposed by the marketing/business group. It has to be analyzed through a structured frame and supported by a business analysis. The following figure explains the main activities to develop a product starting from the business opportunity.
The outcomes of one of the earlier phases of this process the product requirements in alignment with the initial attribute profile, which will build up the basis for the project execution in the later stages. At that stage the team comes to an agreement on the product concept that will have to be validated by consumers by means of market research. The standard that validates market acceptance of the product concept is 70% preference over competition.
10. PRODUCT DEVELOPMENT IN THE COMPANY B

The Company B is a mass production company in component solutions for products. It is in charge of supplying to Company B together with co-workers, through a wide range of materials: glass, steel, plastic, latex, cardboards, lighting, solid paper boards, paper pallet, even assembly, open and close. Its business is global and they have around 800 co-workers. They work in Sweden, Slovakia, and China. Thanks to the cooperation (Company B Trading Offices) they are present at several places around the world. The goal is to be a competence center for selected components, to develop and trade raw materials and components in the Company B range and offer a global sourcing of selected components to its suppliers [72].

It emerged with the name Modul Service in the year 1986. The reason was the need within Company B of lowering costs with the right quality for different components its suppliers use. It has become expert of components’ knowledge, by making this company more competitive; through optimal prerequisites for raw materials and components regarding price, availability, traceability, quality and functionality [72]. The future ambition is uniqueness and customer friendliness. Therefore, Product Development is an essential part to improve.

The product development process is carried out by a group that is situated in Älmhult, its name is Creating Design. The company is supported by a centralized structure. The process is completed with different tools from different strategies such as Lean, Six Sigma. This process has been implemented for 10 years, but actually the process has not been described since the last year. Creating Process has always been based on the quality side. Nowadays, this process is missing the consumer insight.

10.1. Interviewee

The interviewee was a quality development manager. He has a quality’s background and he is in charge of looking for right global approaches and tools to complete the activities during the whole product development process.

He has worked for the Company B more than 10 years, in aspects regarding quality, with suppliers in different countries, for instance China. Currently he is part of quality side within the project owner of Creating Design. He was accompanied during the interview by the process owner within the product development process; he is the responsible for the outcomes and development of the operational process.

10.2. Summary of interview content

The Company B process is called Creating Design; it is named in this way due to the purpose to design, create a flow of information and features to satisfy customers’ needs. It has been implemented for 10 years but actually the process has not been described since the last year. They take advantages from different processes which follow methodologies with different objectives and different tools. They describe that way to carry out the process as: <<trickier for them>>. The company B has its own nomenclature during the processes and makes the process more complete.

It is a checkpoint process. Every certain time the process is checked and there are two options: go/not go. There is not an intermediate site. There is not a list to know in which grade are reached the objectives during the process. It is seen by the company as a failure to improve in future processes. Each stage counts on twenty/thirty activities
and a set of tools support them. The initial point of the process is the business opportunity and the end point is the mass production.

The innovation belongs to daily operations. There are some roles dedicated to innovate and study the business potential to innovate. The company would like to innovate, however sometimes there is a business potential but the feasibility or constraints are not so clear. These roles in charge of innovation are not motivated to innovate by any reward system.

The customer information is quite difficult to find out. It is delimited because the necessary feedback should be about the raw materials, it should not be about the end product. Actually the feedback, which is found out more easily, is about the end product. Surely, the feedback of furniture is essential for the customers; it is provided by surveys after purchasing and it works quite well. The Company B creates its own index to evaluate the performance. These surveys from card of this company have questions about the usability and then, they are compiled. In spite of they do not focus on a sample, the real customers of the company B participate in the survey. The information also emerges from suppliers, because they have also useful information about raw materials. Therefore, this company is part of a flow of shared information.

Managers try to think about improvements of processes, the implementation is not from scratch. It is a continuous improvement. Nowadays, most important failures are: the big between real processes and expected processes, the risk analysis during processes and a lack of customer insight during the whole process. These problems approach the Company B to the idea of Design for Six Sigma, because it is related to customers’ needs. They emphasize: \textit{the success of prior implementations of this real solution, also that it has bear on mind customers’ satisfaction and the interesting suggested tools by DFSS to apply}.\textit{ }

Creating Design is carried out by supply manager, purchase, sustainable, technical and market managers and they run on the complete process, working on a global idea of quality, price, delivery (product availability), and sustainable products. The process owner keeps under control the different roles. The definition of quality is to get more than customers want. It is overcome the expectations of customers. Interviewee agrees: \textit{if we focus only one aspect, for instance quality, they will not get a complete customer satisfaction, the customer voice is being forgotten a lot of times during the several stages}. The product development process is carried out by this group of people with different skills in order to complement them. All of them work and collaborate at the same level.

There is a project leader who has competences on technical and commercial skills. The intention is to have a complete idea about the project, about the customer’s needs. The Company B looks for someone who is able to lead. This person is the owner of the control of the flow of information, delimits the task of everyone and the control of the communication within the group. Creating Design could be complemented through a training tool or documented tools as a SCRUM in order to manage relationships, meetings and workshops. Moreover there is not an especial training; they only add new perspectives to know from their specializations the customer needs. The different managers who create the group need to know with are the right tool, right moment and the right place to apply tools and cover a broader range during the process.
12. ANALYSIS OF DFSS AND THE PRODUCT DEVELOPMENT PROCESS OF THE COMPANY A

12.1. Quality

Quality’s meaning

Company A: the concept of quality focus on reliability and performance in its products.

DFSS: quality focus on effective and efficient processes within Six Sigma capabilities.

In both cases, the quality process runs in parallel with product development process

Process’ Quality

PDP and DFSS drive quality measurements, predictability and improvements in early design phases. The first phase of the quality process in PDP is the quality plan. Both methodologies have a continuous control during the process, through several tools. PDP has quality controls through the chain of figure 1. The task is not just to avoid failures.

12.2. Product Development

Process’ model

The implemented product development in the Company A is structured in phases through checkpoints (CP), on each CP there is a meeting to check if the commitment is being reached. Stage – gate methodologies summarize the critical success for the company before a certain checkpoint and analyze the future success potential of following stages [28], [42]. It could be similar to a roadmap. DFSS is also carried out by similar methodologies to roadmaps, standardized stage-gate model [63], such as: DMADV, DCOV, DMADIC, DCCDI, DDOV and ICOV. Both models intend to create a robust, reliable design and they should be related to customer demands. DFSS and PDP cover the whole process of product development but in DFSS there is not an agreement about the start point and end point of the process. Employees of the Company A consider that the start point of product development is the stage where the opportunities are provided as inputs and at the end point, the mass production is the output.

In the current situation, most organizations base their DFSS process descriptions on different PD process models. There is not an agreement about identifying one optimal PD process model or if the DFSS implementation implies removing the old PDP and introducing DFSS from scratch. On the other hand, the new approach of the Company A has the purpose to unify all the practices within the company to come to one optimized process.

Tools and techniques

Both methodologies break the whole activity down into simpler activities by different tools. They are aware of the type of isolated tools and the new trend is to use of all them to cover a broader field. For instance, the Company A works on its consumer insight through several steps and tools. The table 3 provides examples of tools used by the Company A to define the business opportunity based on customers’ needs.
DFSS is supported by different tools and techniques to help the process in order to be more efficient and effective during its evolution. There is freedom to use a certain set of tools; it will depend on the purpose within the company. There is a novelty about using tools which focus on customer needs; they create the baseline to work within DFSS’s framework. PDP is also supported by tools.

### Cross functional process

The new product development model of the Company A, as well as DFSS, is cross functional, relating upstream activities with downstream activities during the plan of action, through continuous feedback and checkpoints. It is related to create team-oriented projects. The new process implies change management principles.

### Outcomes

Both processes reduce design changes and iterations after the design phase by means of a better controlled requirements management in the early stages

DFSS uses own outcomes to reevaluate the coming process, that is, it is focused on measuring the results of their improvement efforts. The same activity is realized by the company A through systematic knowledge management. It includes an analysis of the mistakes that were made previously. There is verification, not only an optimization, in order to get a continuous improvement.

### 12.3. DFSS

Quality is the primary driver in the PDP of the evaluated company as well as DFSS. They are not creating a new PD, they are just adjusting the existing process to the new business environments. Table 4 shows the expected outcomes of Company A and DFSS [26]:

<table>
<thead>
<tr>
<th>Task</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing business brief</td>
<td>Look for business opportunities: compilation of information</td>
</tr>
<tr>
<td>Attribute profile</td>
<td>Needs’ rank, identification of competitors, comparison between actual / future situation</td>
</tr>
<tr>
<td>Design Prototypes</td>
<td>Evaluate customers´ opinion</td>
</tr>
<tr>
<td>70 %</td>
<td>Market research methodology to validate customers´ preferences</td>
</tr>
<tr>
<td><strong>DFSS</strong></td>
<td><strong>Company A’s PDP</strong></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Drives the customer- oriented design process with Six- Sigma capability</td>
<td>Consumer insight is at the core of Company A’s product development</td>
</tr>
<tr>
<td>Predicts design quality at the outset</td>
<td>Predicts design quality through Quality Plan</td>
</tr>
<tr>
<td>Match top- down requirements flow down with capability flow up</td>
<td>Alignment between strategy and following stages, by relating upstream and downstream activities</td>
</tr>
<tr>
<td>Integrate cross functional design involvement</td>
<td>Integrate cross function design involvement: cross functional teams</td>
</tr>
<tr>
<td>Drives quality measurement and predictability improvements in early design phases</td>
<td>Drives quality measurement during the CP1, CP2 through Quality Plan, SCR- monitoring, Quality verification and reliability.</td>
</tr>
<tr>
<td>Uses process capabilities in making final decisions</td>
<td></td>
</tr>
<tr>
<td>Monitor process variances to verify that customer requirement are met</td>
<td>Monitor process variances to verify that customer requirement are met throughout the full process. Change request are dealt with according to changes management rules agreed upon at the beginning.</td>
</tr>
</tbody>
</table>

Table 4. Comparison of main elements of DFSS and PDP of the Company A

Currently the purpose is to optimize the local processes practice into global product development process, to support a global company and to further reduce time to the market. So, there is a clear divergence between DFSS and PDP’s main purpose.

The overall goal of DFSS is expressed in terms of cost reduction, while PDP is more focused on time reduction.

PDP and DFSS are seen as the best possibility of design practice to achieve competitive advantage and business excellence by the Company A and the theory’s DFSS, respectively [64]. Therefore both concepts are becoming popular in the market, in spite of lack of information on how DFSS works.

12.3.1. DFSS- Customer Satisfaction

**Business opportunity**

The compared models are driven by consumer insight. It implies methodologies and tools to control customer knowledge and take advantages of it. DFSS is not prescriptive to use a precise toolbox. The Company A relies on a set of activities that translates human needs into product requirements. Both start their project from a business opportunity. This opportunity is created by expectations of customers. They are structured so that customer requirements can be borne in mind during all the process, through continuous feedback and cross functional team in PDP or through a set of tools in DFSS such as (Kano Model, QFD).

**Customer’s Feedback**

Effective customer care and preservation of long-term relationships with customers, after purchasing, are essential factors to get a faithful customer base and loyalty. DFSS suggests a continuous feedback during all the process, but it is described in an undefined way.

Within this framework of feedbacks, the DFSS’s theory does not focus specially on the other feedbacks such as costs. For mass-customization companies, it is really important, because the target market has been known for a long time and the innovation is quite difficult.
12.3.2. DFSS- Innovation

**Innovative organization**

The company A carries out an interdisciplinary practice to innovate and to become the customer’s choice. In 2011, they created the Innovation Triangle [66]; it promotes closer collaboration within the Group between the marketing, R&D and design. The purpose of this collaboration is to achieve successful products, by promoting synergies globally and reducing the time to the market. Collaboration needs a flexible and a dynamic group to achieve products and take risks.

![Fig.14. The innovation triangle [65]](image)

**Innovation process**

Innovation is embedded in the whole process starting even before the project comes to product development stage. Opportunities are captured already during the planning phase. Instead, DFSS is an attempt to integrate innovative process into current product development processes; some companies get the integration thanks to Quality Gates which provide the control to deliver innovative outputs [67]. The product portfolio plan reflects somehow the strategy of the Company.

12.3.3. DFSS- Roles

**Cross functional teams**

The core values of the Company A are: passion for innovation, customer obsession and drive for results. The passion for innovation drives to encourage cross-functional teams and act with speed and flexibility [60]. It is a way to learn and get inspiration from each other. DFSS and this company work in cross functional processes, where the activities upstream and downstream are related, and there is a continuous interaction between people from different fields. In fact, both processes have the objective to manage the work and collaboration between cross-functional teams. DFSS and PDP control a parallel structure of improvements versus an integrated structure [63]. PDP and DFSS organize their roles in order to understand the development process.

The main factor in both processes, in order to carry out a cross functional team, is to assign clear tasks to everybody within the project team. Theory of DFSS puts more weight on what a team is supposed to do and deliver.
As theory explains, **DFSS emerged from a lack of consumer insight over the whole process, by trying to improve processes; consequently quality backgrounds started to be preferred.** Previously, product development projects were mainly carried out by R&D as an essential role for projects, but actually this concept is **changing because all the skills are necessaries** in cross functional teams.

**Training**

**Specialists need training to get used to this new way of working.** DFSS is based on Six Sigma role structure, and they support a training of statistical techniques as well as the practice of applying these tools in real processes. In spite of the different purposes of training in both methodologies, the length is undefined in both models and everyone, within the company. In the Company A they have to find his/ her way to communicate.

There are career paths especially designed for professional project managers according to PMI standards within the Company A. GPDP is a department and actually they monitor the correct implementation of the newly introduced process and opportunities for further improvement. Different project groups are continuously exchanging information about how the relationships are working, if there is any room to improve or if there is a success to spread to the rest of the groups. Instead, DFSS needs to get an accreditation to practice management, through exams, supporting letters or a minimum of successful achieved projects.

**Role´s structure**

PDP and DFSS´s organizations suggest **horizontal relationships** rather than vertical, in spite of the hierarchy of Black Belt Roles of DFSS. The black Belt structure is formed by three different roles: Sponsor, Black Belt and Green Belt. On the other hand, PDP is integrated with a new role: Project Manager, there is indeed a clear project organization based on degrees of responsibilities, ensuring a direct flow of communication between the project manager and the different intermediaries. The intermediary is the spokesperson of each expertise area and they represent the group. Within these groups there could be a suitable hierarchy, but the flow among intermediaries and project manager intends to be horizontal.

This new role of **Project Manager** that been revised. Traditionally, a Project Manager would come from the R&D departments; now the role covers a broader perspective. He or she makes sure that the project is carried out according to the agreed targets in terms of time, cost and quality. In doing this he/she needs to have a full understanding of the process to make sure that the flow is working. It is not similar to Sponsor´s task, due to its role´s definition: **supports the project group with a top commitment by facilitating the decision-making phase.** Sponsor role checks the results of project tollgates and encourages to initiate relevant project steps in DFSS [68], [69]. Thereby, the difference is quite big between both roles, because the new project manager is part of the group and does not support project group with a top commitment.
13. ANALYSIS OF DFSS AND THE PRODUCT DEVELOPMENT OF THE COMPANY B- CREATING PROCESS

13.1. Quality

Quality’s meaning

The Company B: quality focus on overcoming customers’ expectations.

DFSS: quality focus on effective and efficient processes within Six Sigma capabilities.

In both cases, the quality process runs in parallel with product development processes.

Process’ quality

Creating Process and DFSS drive quality measurement, nevertheless DFSS emphasis on predictability and improvements in early design phases and Creating Process deals the predictability and improvements at the same level through checklists during the whole process.

DFSS emerged from Six Sigma capabilities. It is able to measure quantitatively and qualitatively failures and achievements. For the Company B, it is a challenge, because it is quite easy to measure if the goal has been achieved but it is not so easy to measure the level of achievement if it is not complete.

For both processes, the task is not only to avoid failures. Furthermore, it is to overcome the customers’ needs satisfactorily.

13.2. Product Development

Process’ model

The process called: Creating Design is structured in phases through checkpoints. Every certain time the process is checked by lists. There are two options: go / not go; there is not an intermediate set. It belongs to stage- gate methodologies [71], [30]. It could be similar to roadmaps. DFSS is carried out by DMADV, DCOV, DMADIC [65]; all the possibilities also match up to a stage - gate model. Nowadays, both models are based on Six Sigma capabilities in order to create a robust and reliable design. DFSS and Creating Design cover the whole process of product development. However, in spite of the ambiguity to define the start and end point of a process, such as DFSS, Creating Design defines the initial point of the process as the business opportunity and the end point is defined as the mass production.

The Company B’s process has been implemented for 10 years, it has created its process taking different parts from different methodologies. It is trickier to have the own nomenclature. Different tools are chosen to complete the process, from different strategies. In DFSS, there is not an agreement about identifying one optimal PD process model nor if the DFSS implementation involves removing the old PDP and introducing DFSS from scratch. The Company B is improving the process from already implemented processes; for instance they are missing the customer voice and there is a possibility: an approach to the tools of DFSS.

Tools and Techniques
Creating Design and DFSS break the whole activity down into simpler activities by different tools. Each stage of Creating Design counts on an amount of activities (around 20-30 activities) and tools from different methodologies are used to cover a broader field.

Creating Design is similar to Six Sigma, it is missing the customer voice, however, DFSS supports a new set of tools that boosts customer insight. For the Company B, the tools during its product development process are the base to cover the different areas in order to complete the customer satisfaction: quality, price, delivery and sustainability.

Cross functional process

Both product development processes are cross functional, relating upstream activities with downstream activities. Creating Design is being carried out by supply manager, purchase, sustainable, technical and market managers that run on the complete process. They work on a global idea of quality, price, delivery (product availability), and sustainability. If they work in only one aspect, for instance quality, they are not able to complete the customer satisfaction.

13.3. DFSS

Both methodologies run on a product development project that comes from a quality perspective, it approaches to Six Sigma; and the new strategy is to be closer to the consumer and ensure quality. There is a clear convergence between DFSS and Creating Process´ main purpose. Table 5 shows the expected outcomes of the Company B´s process and DFSS [28]:

<table>
<thead>
<tr>
<th>DFSS</th>
<th>Creating Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drives the customer-oriented design process with Six-Sigma capability</td>
<td>Try to create a flow to satisfy customers´ needs, customer voice is often missed</td>
</tr>
<tr>
<td>Predicts design quality at the outset</td>
<td>There is not a special prediction of design quality at the outset</td>
</tr>
<tr>
<td>Match top-down requirements flow down with capability flow up</td>
<td>There is a continuous feedback and reviews of checklists that links top-down requirements</td>
</tr>
<tr>
<td>Integrate cross functional design involvement</td>
<td>Integrate cross functional design involvement: cross functional teams</td>
</tr>
<tr>
<td>Drives quality measurement and predictability improvements in early design phases</td>
<td>Carries out a checkpoint process, by evaluating necessary requirements by checklists.</td>
</tr>
<tr>
<td>Uses process capabilities in making final decisions</td>
<td>Aims to use a more complete tool in making final decisions (SCRUM)</td>
</tr>
<tr>
<td>Monitor process variances to verify that customer requirement are met</td>
<td>Customer´s insight can be implemented and have in mind at every stage of the process, through different tools, but it is a phase to improve.</td>
</tr>
</tbody>
</table>

Table 5: Comparison of main elements of DFSS and Creating Design of the Company B

The goals of DFSS and the Company B are expressed in terms of cost reduction. Both processes get a continuous improvement.
DFSS is seen as the best possibility of design practice to achieve competitive advantage and business excellence by many companies and the theory’s DFSS [66]. The current project in the Company B has been implemented for a long time ago. It has been improved through tools of different models that were considered the best possibility. These tools are being used by other companies due to the ensured success, these tools are real solutions and they are able to relate the process to customer insight. Therefore both concepts are becoming popular in the market, in spite of lack of information on how DFSS works.

13.3.1. DFSS- Customer Satisfaction

*Business opportunity*

The business opportunity is the start point of Creating Design and DFSS. Both attempts to introduce tools in order to control customer knowledge and take advantages of it. DFSS already focus on customer needs; and Creating Design, since the difficulty to introduce the customer’s need in the process, is approaching to customers’ needs thanks to suitable tools. The Company B require users’ information about raw materials, not about the complete product; still the feedback that comes from the customer about the final product is easy. In this aspect, DFSS does not define which are suitable products / markets/ companies to put into practice successfully. Up to now, the Company B focused on quality and prices, by missing the whole customers’ perception of the product.

The Company B’s process intends to be structured so that the customers’ needs can be implemented and have in mind at every stage of the process, through different tools. At a certain stage of Creating Design there is nothing to change because the investment is so high to come back to initial phases. There is a continuous feedback with the prior stages, and the checkpoints create these feedbacks if the activities are not completed or close to the customer satisfaction.

*Customer’s Feedback*

To introduce customers’ requirements into the processes, DFSS and Creating Design, is necessary the feedback; in order to take care and get the preservation of long-term relationships with customers. The feedback of furniture is essential from customers; it is gotten by surveys after purchasing. It implies the customers in the process and it works quite well. The Company B shares information with suppliers due to they have also useful information about raw materials. DFSS defines the continuous feedback in an undefined way.

Both processes focus on quality and customers’ feedback to complete and get the success.

13.3.2. DFSS- Innovation

*Innovative Organization*

The Company B has some roles dedicated to innovate. There is not a clear relationship between the group of the project owner and the roles in charge of innovation. When there is a feasible business potential, Creating Design and group in charge of innovation start to collaborate. Instead, DFSS promotes closer collaboration within the Group, for instance, between the marketing, product development and design units.

*Innovation Process*

DFSS and Creating Design work in parallel the activity of innovation into current product development processes; they get the integration thanks to quality gates which provide the control to deliver innovative outputs. The innovation belongs to daily operations and the aim is to reach the highest business potential. Creating Design uses a diagram to evaluate the opportunities. Figure 16 is the diagram to evaluate these opportunities.
Business Potential

Fig. 17. Diagram of innovation of the Company B

13.3.3. DFSS - Roles

**Cross functional teams**

The Company B carries out the product development project by a group of people with different skills, in order to complement them. All of them are working and collaborating. Actually the group is formed by: Supply Manager, Purchase Manager, Sustainable Manager, Technical Manager and Market Manager [72]. The intention is to get a complete idea about the project, about customers’ needs. It is a way to learn, to get inspiration and do not forget the four main aspects to achieve the customers’ satisfaction: quality, price, delivery and sustainability. DFSS and the Company B work in cross functional process. The activities are continuously related, therefore there is continuously an interaction between complementary skills. The companies, that are in charge of these processes, aim to manage the collaboration of cross- functional teams.

In these cross functional teams, assigning clear roles and responsibilities is important. The Company B’s employees know their roles, and the important responsibility is the way to communicate within their context.

DFSS’s theory puts more weight on what a team is supposed to do and deliver [26]. The project owner is in charge to control the information’s flow within the product development’s group.

**DFSS emerged from Six Sigma, by trying to improve processes; consequently quality backgrounds started to be preferred.** On the other hand, in spite of Creating Process has been focusing on a quality perspective for a long time; nowadays they do not have any preference to choose any background, but knowing to lead is an essential factor for this company. The choices are changing because all the skills are necessary in cross functional teams. Reactions, while risks and innovative ways are taken, are limited with only one background. Leadership is becoming a major skill to manage and drive the group.

**Training**

Specialists need training to get used to this new way of working, but the content is not the same. DFSS is based on Sig Sigma role structure, and they support a training of statistical techniques as well as the practice of applying these tools in real processes [26]. However, the Company B does not require any special training; they need to bear in mind the customer needs from their expertise area. They need to know which are the right tools,
the right moment and the right place to use them. It is an important task to delimitate the task of everyone. During taking decisions, they are working to talk about the decisions, to listen to other specialists about the problem, and then, the task leader takes the decision. Actually, they do not have anything to control the flow of information or the right way to communicate between the groups. But they interviewees suggest, as the perfect solution, a training and documented tool: it is SCRUM [71].

There is not an accreditation to act in these roles within this company, they are performing their work and they are controlled by the process owner. Instead, DFSS needs to get an accreditation to practice management, through exams, supporting letters or a minimum of successful achieved projects.

**Role’s structure**

Creating Process and DFSS’s organizations suggest a horizontal relationship rather than vertical, in spite to hierarchy of Black Belt Roles of DFSS and the project leader’s role in this company. The black Belt structure is formed by three different roles: Sponsor, Black Belt and Green Belt. The group of the Company B’s process is formed by: Supply manager, Purchase Manager, Sustainable Manager, Technical Manager and Market Manager. All of them are working and collaborating at the same level. There is a task leader, he/she is the project leader. This person has competences on technical and commercial skills. This person must know how to lead (as a leader). He/she needs to control the flow of information. It could be similar a project manager.
14. PROCESS COMPARISON: PRODUCT DEVELOPMENT PROCESS IN THE COMPANIES A AND B

The companies A and B are mass-customization companies; the first one is a decentralized company that is dedicated to household appliances and also appliances for professionals; and the second one is a more centralized company, which is dedicated to provide component solutions for products. Both manage a broad range of solutions and bet on improvements of product developments for achieving the success. The complexity of the control in both companies is huge.

In order to make the conclusion about the use of DFSS easier, the next table shows the expected outcomes in both companies.

<table>
<thead>
<tr>
<th>PDP of the Company B</th>
<th>PDP of the Company A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Try to create a flow to satisfy customers´ needs, customer voice is often missed</td>
<td>Consumer insight is at the core of the product development of the company A</td>
</tr>
<tr>
<td>There is not a special prediction of design quality at the outset</td>
<td>Predicts design quality through Quality Plan</td>
</tr>
<tr>
<td>There is a continuous feedback and reviews of checklists that links top-down requirements</td>
<td>Alignment between strategy and following stages, by relating upstream and downstream activities</td>
</tr>
<tr>
<td>Integrate cross functional design involvement: cross functional teams</td>
<td>Integrate cross function design involvement: cross functional teams</td>
</tr>
<tr>
<td>Carries out a checkpoint process, by evaluating necessary requirements by checklists.</td>
<td>Drives quality measurement during the CP1, CP2 through Quality Plan, SCR- monitoring, Quality verification and reliability.</td>
</tr>
<tr>
<td>Aims to use a more complete tool in making final decisions (SCRUM)</td>
<td></td>
</tr>
<tr>
<td>Customer´s insight can be implemented and have in mind at every stage of the process, through different tools, but it is a phase to improve.</td>
<td>Monitor process variances to verify that customer requirement are met throughout the full process. Change request are dealt with according to changes management rules agreed upon at the beginning.</td>
</tr>
</tbody>
</table>

Furthermore, the Appendix 1 provides an overview of all the aspects which have been evaluated in prior comparisons of these methods with DFSS, here instead the comparison is between both methodologies in order to provide a clear idea about the similarities and differences and, then starting the discussion.

It must take into account the different points of view of interviewees due to the different role within the company. Company A´s information was provided by Project Manager and the Company B´s information was provided by a Quality Project Manager within the group, he is a supervised employee by the project manager.

In spite to be mass-production companies, the products are completely different and the characteristics of each company are distinct. Due to the difference between purposes, they choose different strategies to carry out the product development. The Company A is a decentralized company and misunderstandings were its major problem; they caused longer time to the market, therefore it decided to upgrade the process. Instead, the company B is a centralized company, so the need to become a global company does not worry. However, It missed the customer
insight; consequently this company decided to implement Creating Design. Therefore, the reader could start to think that Creating Design (the Company B’s process) is more similar to Design for Six Sigma than the Product Development Process of the Company A.

The existing failures related to product development are also reasons to change the current product development process, so they are important and it is worthy of evaluating:

<table>
<thead>
<tr>
<th>Company A</th>
<th>Company B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex communication within the organization</td>
<td>Forgetting the customers’ voice</td>
</tr>
<tr>
<td>Big amount of different projects that create misunderstandings</td>
<td>Difficulties to evaluate the level of achievement of objectives</td>
</tr>
<tr>
<td>Lack of efficiency</td>
<td>Big gap between real processes and expected processes</td>
</tr>
<tr>
<td>Long time to market</td>
<td>No control of flow information</td>
</tr>
<tr>
<td>Mass confusion</td>
<td>Lack of successful risk analysis</td>
</tr>
</tbody>
</table>

Table 7. Failures of the Company A and Company B related To the Product Development Process

Due to these different failures during the process, the companies focus on different aspects and some clear differences are created as: the purpose of the upgrade product development process, the feedback about these failures and the training within the organization.

The following sections will analyze the compiled information in the theoretical part and the information on companies.
15. DISCUSSION

In this section both methodologies, the companies´ product development processes will be subjectively compared and analyzed within the framework of DFSS in order to build the final conclusions and shed light on the initial hypotheses. The link should be obvious in the entire report. Therefore, the discussion will be divided into parts directly related to the two initial hypotheses about Design For Six Sigma.

15.1. Product Development Process

The quality of a process influences directly on the quality of products [6], [8]. Therefore, talking about quality of products without relating them to the processes´ quality does not make sense. To have an effective and efficient process makes obtaining successful goods easier. Thus, both companies A and B agree when they say: << we look for reliable products >> (the company A) and << we should overcome customers´ expectation >> (the Company B); because these are their objectives regarding quality and the product development process is the first to be improved to achieve successful products [13], [14].

Descriptions of DFSS´s processes are based on different process models and all of them are roadmaps [18], as well as, the companies product development processes. This structure makes DFSS method easier, by making it robust and reliable at the same time, in order to control the customers´ requirements, like it has been shown through the definition of DFSS roadmap in the literature review, chapter 8. Moreover, this structure allows to distribute the efforts of consumer insight from the first stages of the product development process. Checkpoints can be distributed in distinct ways; there is freedom depending on requirements. None has been proved to be better than the others, as long as, they fulfill the goal and the customer insight is a success. A roadmap is a good and simple way of showing how a chain works. Because it is a base line to carry out the project because you must make sure to reach some requirements, otherwise, it could be a waste of time.

Furthermore, the company A and B´s processes have reached their positions in today´s market thanks to the improvements of prior processes; thus, they have managed to keep the advantages and be competitive doing their best. In this way the implementation is not so hard for the employees because the terms are already known. Keeping the prior structure with new tools and improvements is trickier because it is a way to create a competitive process, difficult to reach for the competitors. Previous processes were profitable in this evaluated companies and new goals are being achieved thanks to improvements; for instance, a global process with a reduction of time in the Company of A and a better customer insight in the company of B. The choice of removing the old PDP and introducing one from scratch is quite hard from the point of view of the student, because the company cannot stop and lose profits, it has to continue to operate and the training for the employees requires time. It will depend on the starting point of the current methodology to implement the new process, if it is suitable. Since most organizations working with product development have a long background in the field it would be a waste to abolish the existing structure. For the company B : << improving the exiting methodology could be a way to mature>>.

To link any process to DFSS is more suitable from a perspective of quality and customers´ approach. Processes in both companies do not work with a known methodology instead, they try to merge complementary processes or upgrade previous processes that work efficiently and get a continuous improvement.

The company A looks forward to becoming a global company without forgetting customers´ insight. The process does not follow the DFSS. DFSS is described by the interviewee as a process that emerges from a quality perspective, from managers that own a quality background and influence the chosen methodology. It is seen: << as ideal for projects which work better locally rather than globally, with the purpose of approaching customers >>. On the other hand, the Company B is more interested on DFSS because its goal is to bear on mind the customers´
needs. The inerviewee describes it as: << a real and successful solution in complex projects and big organizations >> and they point out the interesting tools to apply. With these opposite points of view of DFSS and from the knowledge acquired in the literature review by the student, DFSS could work and be efficient in big projects where the control and management are more difficult and the customer could be easily forgotten during the whole process [25], [26], [27]. In spite of the Company A has created a new department in charge of optimizing the product development process within the Company globally, DFSS could be useful to create a global company by structuring all the steps and orienting them to the customers. Therefore, different opinions about this can be found and it is hard to trust in a process and implement it in a company at the beginning. The complexity is huge, overall in small companies.

The fact that DFSS is based on tools and techniques, roles and processes [28], proves that it is based on the new idea of total quality management by covering the whole project and all the departments. DFSS enables to gain the right customer insight through quality of the process as well as the engagement of everyone in the organization. Thus, it follows a line of success.

DFSS, the company A and B’s purposes are divergent. They are expressed on terms of cost reduction and time reduction respectively but are related because once the time is reduced the cost are reduced consequently. By structuring processes through checkpoints the reduction of time and costs are evaluated easily. The companies development processes enables to measure the results as well as the efforts to improve in order to obtain a feedback about advances and progresses during development. Feedbacks provide the check of an alignment between the strategy and all following stages; it makes decision making easier and enables to overcome the process’s capability. A measure of results allows going beyond consumer’s expectations and identifying attractive quality elements [15]. Overcoming customers’ needs is the point to differentiate the portfolio of the company so DFSS could become a good methodology to differentiate itself from the rest of competitors.

Customers are the main piece of the company. There is a better tracking in the Company A thanks to its definition of business opportunity through the Attribute profile. However, the company B is lagging behind and they are trying to improve this aspect. It is important to realise the difficulty of getting customer insight on raw materials and components instead of final goods that are directly perceived by customers. Thus, DFSS could be also interested in components and raw materials, making the search of needs easier with the help of a set of tools.

Regarding DFSS’s theory, this methodology is not the most appropriate for a certain kind of goods. However, all of them are oriented to an end user so DFSS is always useful. Otherwise, DFSS is able to support the most difficult product development when the relationship between the product and the customer is not so clear and the customer insight must be deeper; due to the contribution of the set of tools.

DFSS focus on innovative activities. To launch a product to the market is necessary to find a product that satisfies customers, also find innovation and then link them [28]. But it is not always so easy and innovation has to be linked to all the stages during the whole process. Innovation is not only referred to technology but to organizations, relationships, new tools and new strategies all of which appear in consecutive stages [45]. Thus, it is an attempt to integrate the innovative process into current product development processes. DFSS supports this idea and so does the Company B through an innovative group that works in parallel with the project owner. However, in the Company A, innovation is embedded in the whole process starting even before the project comes to product development stage. Besides, the big investment takes place at the beginning during any process. If the investment happens at the beginning the company is responsible for greater risks. Therefore, there should be a tradeoff trying always to satisfy the customer. DFSS advocates having an innovative approach by providing several levels of freedom between each check point of the road map [30]. From the literature review brings up that this structure allows flexibility and creation of an innovative adjusted organization model, but the difficulty to manage grows at the same time.

Everything is not advantages with the roadmap structure, because the achieved complexity is huge and the control rises in each stage. Maybe the reduction of time is more effective, making a control deeper and an accurate tracking; but it becomes a process in which the management is continuous and the control is more detailed. Responsibilities are split into easier activities and therefore the number of people in charge of these processes grows.
The choice of introducing DFSS from other processes speeds up the change and it does not prevent the continued growth of companies. It could become a mass confusion for employees between both processes if the requirements and principles are not clear. Thus, the implementation of DFSS and the process is not so obvious, they depend on a lot of elements within the company.

### 15.2. Roles´ Structure

Success in launching a product depends on the approach to customers. Thanks to this document is presented the importance of each role within an organization for achieving this success in the product development process. The companies development processes organize their roles and their tasks through cross-functional teams in order to understand the development process. The checkpoint process helps control the collaboration between several professionals at the same time by covering some problems and decision making from different sides. It is a way to learn and obtain inspiration from each other. Both companies point out: <<It is essential to know who is expected to do what by when>>, but collaboration is a new field to coordinate. Collaboration can provide a better integration, a long-term vision and a dynamic structure with a strong customer insight during the whole process.

Before relationships were not answered within organizations, it could be a kind of sub-optimization due to different objectives from different departments. Thus, the learning is to know how to act and react in collaboration. Employees cannot be trained to participate in these relationships because each one has distinct behaviors and backgrounds and the training cannot be standardized as Six Sigma’s Black Belt roles. The company A evaluates areas of improvement in the newly introduced product development process mainly on the basis of input and feedback from the various functions active in product development projects worldwide. In this sense the company B is not so developed because despite they realized the possible problems in these collaborations, currently there is not an assigned activity to solve it. They talk about tools as Scrum to manage the process. In this same line roles structure of DFSS, which comes from Black Belt roles of Six Sigma, is working [18], [28], [61]. DFSS program suggests complementing Six Sigma’s training with tools that could reinforce innovation management and lead it to create a real project team [59]. From the personal point of view of the student, surely training on tools use is important, but the knowledge of these tools is part of the task of professionals and if employees were hired they should have a commitment to keep training and learning. This should be part of management knowledge.

Both processes consider as a main factor in the PDP to assign clear task to everybody within the company. Once tasks and roles are assigned clearly, it is easier to achieve a complete understanding because they are part of a global goal and there is not any kind of sub-optimization. The collaboration is a need. Organizations have to be motivated to become knowledgeable on the subject.

Due to cross-functional teams, several backgrounds are working together. Only one background is not enough to manage the process. Previously, there were quality (in Six Sigma projects), R&D (The Company A’s projects) and leaders (The Company B’s projects) backgrounds that supervised processes but they only covered one side of the product. Now everything is changing and companies are able to cover the whole product in all its faces and perspectives. Otherwise, the solution could be incomplete and not so efficient as it would disregard different aspects to achieve the complete customer satisfaction. For instance, in the Company B, they need different points of views: quality, price, delivery and sustainability. Reactions, while risks are taken and innovative ways are being applied, are limited with only one background. It is impossible to have the perfect combination of project members but it is closer to perfection by covering expertise areas that influence the process directly.

Moreover, both processes consider the role of the project manager to be the appropriate one to manage the group. A person is necessary to control the product development process. <<Having an overview is good to understand everything and making decisions>>, by the Company A. This role ensures tasks, and subordinates are able to understand better what the project manager wants and what are the expected benefits. The goal is more transparent for the organization and relationships are controlled by this structure of roles because the flow of information has to reach the level of the project manager. However, it is a hard task and in more complex projects a kind of
hierarchy to divide tasks is essential. While horizontal relationships are kept, having different levels or intermediaries from each expertise field to communicate directly with the project manager could be a good way to ensure a clear and transparent flow of information. Both companies work with these kinds of levels in a horizontal organization and they have good feedbacks with these organizations. The role of Sponsor or Project Manager could be enough to manage the process and also the organization due to its capability to have an overview and control of commitments to achieve the final goal. But the Sponsor has responsibility of top commitments and the new project manager works in parallel with the rest of roles in order to reach their best.

To have accreditations is not enough to achieve the role of Sponsor or Project Manager. PMI standard is used by the evaluated company A and it describes good practices globally recognized credentials that certify project management practice. It should be one of requirements but should not be enough to allow someone be in charge of these responsibilities. Due to their responsibilities they need to possess certain skills to be able to withstand pressure and lead. Otherwise, it is reasonable that people who are more experienced will be able to manage bigger projects and people with less experience will start working with simpler projects. The same strategy is applied in Black Belt Roles [18], [28], [61].
16. CONCLUSION

The methodology covers a wide perspective, even too wide for small companies due to the big amount of work it involves. But mass customization companies should work perfectly with this methodology. DFSS works effectively when the purpose and the big lack within the company is the consumer insight. In these cases, this methodology is able to provide more advantages through these tools [25], [26]. Otherwise in spite of it could be efficient, for some companies could mean less advantages than difficulties. In these cases a combination of methodologies and the use of toolbox of DFSS could be enough. Implementing accurately a certain methodology is not the right solution. Every company has to look for the perfect solution for their problems and then combine all of them. DFSS is a good proof of this combination of tools and techniques [25].

16.1. Product Development process model

Regarding the first hypothesis, there is no need for a uniformed Product Development process model in DFSS methodology. Since the current status is that several different process models are used it can be questioned whether a unified model is needed. From the reasoning line it really cannot be identical in all organizational applications because the initial premises are not the same for every organization. A standardized model blocks new points of view and improvements of the process. It could become a static process without a potential to go beyond the process’s capabilities or innovative ability.

The variability of checkpoints within a roadmap [65] and a set of tools extend the possibilities of using this methodology, which makes it very useful. The lack of a standardized DFSS model allows implementing it in order to complement other existing processes. It could be a trickier way of ameliorating the company’s competitiveness. This suggestion could provide different perspectives to deal with Product Development without the need of a uniformed Product Development process model. Therefore, there is no need to start the new PDP from scratch.

16.2. Core Roles of DFSS

Regarding the second hypothesis, there is not necessary to translate the Black Belt Role’s structure of Six Sigma [18], [28], [61] directly into DFSS. It would be unrealistic because these processes do not look forward the same goal. Six Sigma’s purpose is to avoid failures and the new vision of DFSS goes beyond. This relationship is not that obvious. DFSS adds new perspectives to the training of these roles with other tools that could reinforce innovation management and lead it to create a project team. So Black Belt Roles of Six Sigma could be just a base line to develop new and skilled workers.

There are some similarities related to the Sponsor/Project Manager role but the new companies should be more worried about implementing DFSS successfully, with the essence of a good training on collaboration abilities and creation of a project team, instead of copying the Black Belt Structure and being the responsible of the top commitments. The pressure should not be on translating Six Sigma into DFSS, but on creating skilled people as a result of the training and collaborating.

Roles structure it is questionable whether this knowledge range can be controlled by quality professionals. Thanks to the theoretical part and the discussion it has been proved that only one background is not enough to cover these roles. In spite of their knowledge of different expertise areas, their task is more related to control the collaboration, communication and flow of information within the group. Therefore, it is more about professionals with determined talents, such as leadership, trustworthiness, transparency, ability to empower and enhance professionals, among others.
16.3. DFSS in the Companies A and B

The decentralized nature of the Company A had led in the years to various interpretations of the product development processes, thereby making communication more difficult and adding a high amount of tools. Thus, the existing methodology is completely different from DFSS. DFSS could work perfectly to control the wide portfolio but the problems are related to various interpretations in this company instead of the lack of customer insight, so the existing process is able solve it.

On the other hand, the Company B is missing the customer insight in its model of product development so DFSS could become a support through the implementation of a set of tools in order to improve the flow of information and customers´ voice as to avoid the lack of a risk analysis, the gap between real and expected processes and the difficulties to evaluate the level of objectives´ achievement through the model of roadmap. A good start could be implementing different techniques and tools on already tracking processes and then improving the process continuously.

16.4. Future researches

Regarding future researches this master thesis has studied the implementation and the possibility of effective solutions or failures of DFSS in product development process, covering only mass customization companies. This study should be expanded to other companies to get a final conclusion about DFSS. Numerical data and DFSS process already implemented should provide clear proofs. The current study is more focused on the track of the process and roles but there are still questions, the rest of perspectives that delimits the master thesis about:

- How the tools work. Actually, future research should achieve the knowledge of how they are implemented and work correctly together to cover the whole process complementing each other. A summary of tools to get customer insight through different stages of DFSS should be a good complement.

- One of the challenges in this thesis is the organization. For DFSS and methodologies of the Companies A and B it is a basic piece to work efficiently. It is important to control and evaluate the relationships and how they can improve.

- Actually, it can be questioned whether a measurement system could evaluate the complete fulfillment of DFSS expected results. Furthermore, this measurement system could evaluate the traceability of the process by going beyond iron triangle containing time, cost and functionality.
17. REFERENCES


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[70] Group website of the company B, 2012-06-28


Interviews
Interview, Company A, 12-06-2012
Interview, Company B, 26-06-2012
## Appendix 1

<table>
<thead>
<tr>
<th></th>
<th>Company A</th>
<th>Company B</th>
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<tbody>
<tr>
<td><strong>Quality</strong></td>
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</tr>
<tr>
<td>Quality Measurements in early design phases</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>Predictability in early design phases</td>
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<td><strong>Product Development</strong></td>
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<td>Agreement: start and end point</td>
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<td>✔</td>
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<td>Introduction of the new model from scratch</td>
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<tr>
<td>Break process down in simpler activities</td>
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<tr>
<td>Emerges from several product development processes</td>
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<td>✔</td>
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<tr>
<td>Unify different practices into an optimized model globally</td>
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<td><strong>Tools and techniques</strong></td>
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<tr>
<td><strong>Training</strong></td>
<td></td>
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<tr>
<td>Training</td>
<td>✓</td>
<td></td>
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<tr>
<td>Use of tools and techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Compulsory accreditation to work</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Roles structure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal relationship</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>New role: project manager</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hierarchy of Black Belt Roles</td>
<td></td>
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</tbody>
</table>

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Appendix 2

Interview Questionnaire *

Interviewee:

Role:

Background:

Company:

1. What is the goal of your company?
2. What is the vision of your company?

Product Development:

3. Who is in charge of Product Development Process?
4. How does Product Development department work?
5. Could you describe a general on-going project?
6. Which is the methodology to follow?
7. Which advantages and disadvantages could you find out?
8. What are the start and end point of your Product Development Process?
9. Is the model of PDP cross functional?
10. What is based your PDP on?
11. Which are perspectives to analyze the development of new products?
12. What failures did you realise to change your prior PDP?
13. Do you keep a continuous improvement?
14. Does your PDP any known methodology?
15. Could you say me if you cover these sentences with PDP:

- Drives the customer-oriented design process with Six Sigma capability
- Predicts design quality at the outset
- Matches top-down requirements flow down with capability flow up
- Integrate cross functional design involvement
- Drives quality measurement and predictability improvements in early design phases
- Uses process capabilities in making final decisions
- Monitor process variances to verify that customer requirements are met

16. How is the communication in the PDP?

Roles:

17. Which is your role’s structure?
18. Is there any training program to achieve these roles?
19. Do you need accreditation to work? What is it based on?
20. Is there any preferred background to lead the role’s structure?
21. Do you create cross-functional teams? How are teams formed?

Customer’s Satisfaction

22. How is measured the customers’ satisfaction?
23. How long do you capture the evolution of the customer’s behavior?

24. Is there any sample of customer to define weights and expectations?
25. How do you translate human needs into products’ requirements?
26. Is there any program to knowledge’s management about customers?
27. Which are responsible roles to be aware of customers’ needs?
28. Do you receive any feedback from your users during the whole PDP?

Innovation:

29. How do you manage innovation?
30. How is it introduced in your PDP?
31. How is the innovation considered on your company?
32. How is innovation enhanced within your company?
33. Do you have any collaboration to share knowledge?
34. Which conditions or resource capabilities are constraints to innovate within your company?

Quality:

35. What does quality mean?
36. Which are quality principles within your company?
37. How are processes controlled in your PDP?
38. Do you achieve any quality commitment?

DFSS:

39. What is your opinion about DFSS?
40. Have you ever thought to implement it?

*Initial framework to make the interviews, it was only a guide that evolved into a conversation.