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A Methodology to Transform Small and Medium Companies to Lean Manufacturing Enterprises in Ecuador

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A METHODOLOGY TO TRANSFORM SMALL AND MEDIUM COMPANIES TO LEAN MANUFACTURING ENTERPRISES IN ECUADOR

By

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A Dissertation

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In

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By

_____

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ABSTRACT

The textile industry is an important foundation of Ecuador's economy because of its contribution through the generation of jobs for unskilled labor and tight integration with other industry such as the agricultural industry, livestock, plastics and chemistry. Within this sector is sub sector Apparel, which is taken as a reference and represents 27% of production in the Textile Industry.   The project aims to develop "A methodology to transform small and medium companies to lean manufacturing Enterprises." It seeks to define and evaluate administrative, production and service processes in a textile company which manufactures garment apparel, define problems in these processes, raise improvement plans and recommendations for themselves and determine a simulation model to search for the feasibility of the proposed improvement model designed.   Some of the most important problems identified in the companies in this sector are the following: the high number of errors in production processes described informally by officials; a poor system for inventory control of raw materials; work in processes, finished products, production processes, and a disorganized workplace-office.

ACKNOWLEDGMENTS

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

When studying global production systems, factory environments and the office areas have a strong relationship of interdependence. So when there is a defect-free production, it is necessary that the plant has the correct documentation in the production line at the right time and in the correct amount. This means that you must have a waste-free environment both in the office and in the area of production.(Boardman & Johnson, July 2001). At the same time, the office requires the right product or service at the right time and in the right amount from the factory. In this relationship, for example, quotations and approved purchase orders are sent to the customers with both product quantity and product delivery time based on the efficiency of the factory process. Furthermore, the shop floor depends on the efficiency of document processing to get sales orders on time and to ensure an accurate amount of raw material when it is needed.

Enterprises want to reduce lead time to the customer, (Boardman & Johnson, July 2001) and this can be achieved when a lean office works with a lean factory, thus increasing product quality.   A company must implement radical changes to compete and grow. (Underdown, 1997).   The importance to implement lean office (Barcia, 2003) and lean manufacturing("Lean System Implementation," 2012), as a joint strategy, in their business has been increased, but companies in Ecuador don´t know about these issues. The Methods, the concepts of lean manufacturing, and lean office are poorly understood in Ecuador, and in this Dissertation, there will have an opportunity to introduce, and apply different methodologies for a specific sector of the Small and Medium Enterprises (SME), the textile sector.   Little literature about the business processes has been developed in Ecuador, and this study will show different results; among them are total lead-time consumed, from

receiving the request for the products to delivering the products to the customer, different processes, documentation, etc.

In this Dissertation, some strategies for the shop floor, such as "5S" called for Sort, Systematize, Shine, Standardize, Self-Discipline, words, Visual Management, Quality at the source among others, are related to be applied in a particular textile enterprise (SME). These methodologies are used extensively and are related to developing a new methodology to apply in SME´s Ecuadorian companies.

1.1   Introduction to the Ecuadorian Textile Sector.

The textile industry constitutes an important pillar of the Ecuadorian economy due to three main aspects: the source of employment, the demand for unskilled labor and the integration of this industry with other industries (agriculture, livestock, industry plastics, chemicals).

The textile industry contributes significantly to the growth of the manufacturing sector representing approximately 14% of GDP in 2009 this sector contributed about two percentage points contribution to GDP has remained constant for 10 years (ECB, 2010). Also, the manufacturing industry of textiles, clothing, and leather goods accounted for 3.5% of the total manufacturing output in 2007, in turn, constituting an important source of employment. 11.5% of persons employed in the textile manufacturing industry is in the manufacturing of clothing increases labor to more than 41%. In 2012, it represented nearly 1% of the Gross Domestic Product of Ecuador. In 2013, the sector represented nearly 555 million dollars, given an amount of 155 million dollars for manufacturing of apparel.

This shows the importance of this industry as one of the pillars of Ecuador's economy, and, as a result, is a heavy source of employment. Despite the good performance that the industry has had in recent years and its impact on employment and government incentives and safeguards to imports, the textile companies must improve their internal processes to meet the competition of imported products and the challenge of entering new international markets, thus generating more jobs and helping to improve the country's economy further.

(555.8 Million Dollars)

- Spinning, Weaving and Finishing of Textiles
- Manufacture of wearing apparel, except fur apparel
- Footwear Manufacturing
- Manufacture of other textiles
- Manufacture of fabrics and knitted and crocheted articles

35.0%

27.0%

15.1%

10.2%

9.6%

3.0%

0.1%
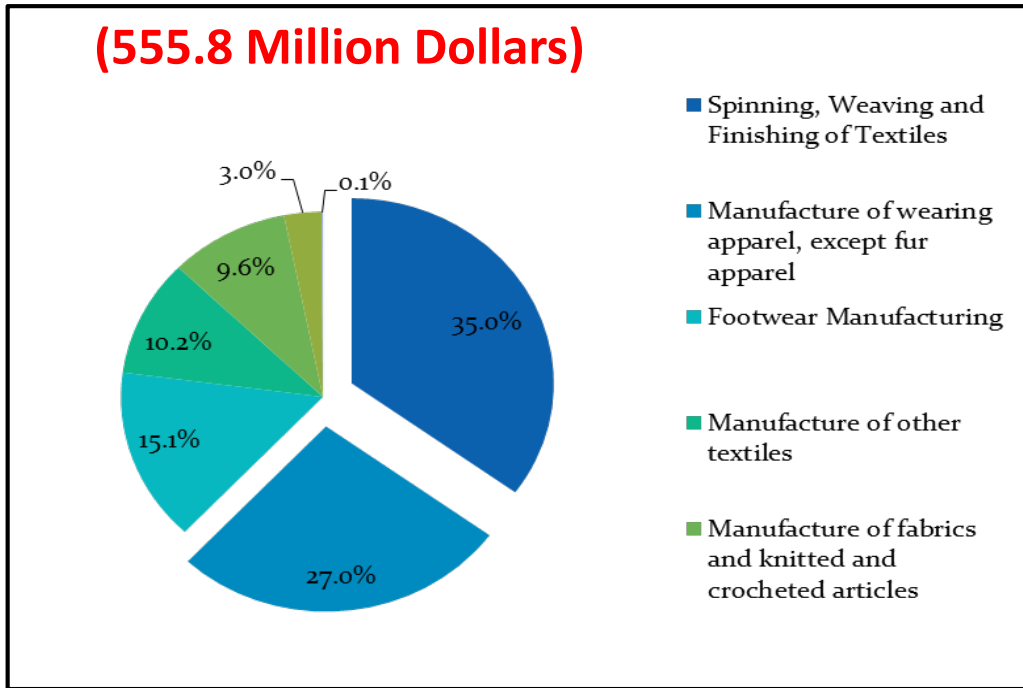
Figure 1.1. Textile Sector in Ecuador, 2013.

Despite the importance of the Ecuadorian textile industry to the economy and job creation, there are serious problems facing this sector. Within these, there are both internal and external problems, considering the latter as less controllable due to governmental issues, legislative, technological, social and economic (Marco, June, 2010).

The lack of investments in technology to increase production volume (Marco, June, 2010), higher prices of inputs (El Comercio, 2010), the wage hike (Ecuador), December 2010), rigidity in the labor system and the new tax rules (HOY, 2008), are just some of the problems facing this sector in recent years. As the solution to these problems are not available to the companies but owned by the state, only the government can reduce the negative impact on contingency plans.

The internal problems of Ecuadorian Textiles affect the productivity and efficiency in resource utilization for companies in this sector. Some problems that exacerbate the sector are as follows: a high number of errors in production processes described informally by

officials, a poor system for inventory control of raw materials, work in process, finished product and production processes, and a disorganized workplace.

The sector's problems, both internal and external, include low competitiveness which produces substitute products from foreign countries. The causes of many controllable problems take their roots in the different business processes such as these: Administrative Process, Manufacturing Process and Process Service.

One of the ways to manage better and simplify the flow of processes for Administrative, Manufacturing, and Services is to develop an Integrated Definition Methods (IDEF0) model. The IDEF is a functional model of the said method, which is designed to plan decisions, actions, and activities of systems, such a specific textile company. "IDEF0 is a widely used technique for the structured analysis and design of systems. Its use in improving the productivity and communications in computer integrated manufacturing systems and, more recently, as a tool for business process reengineering efforts are widely documented." (David A. Marca, 2006). Meanwhile, the IDEF0 model is also very efficient in establishing the scope for functional analysis (Yanlei, Wuqiang, Shuang, & Jin'e, 2009). Basically, the contents of the proposed IDEF0 model define the processes of a particular manufacturing company in the textile sector.

1.1.1   Ecuador

Ecuador is a country located in the northwest region of South America. It has an extension of 283 520 km². Its capital is Quito. Ecuador is the eighth largest economy in Latin America, the seventh in South America. Guayaquil, Quito and Cuenca are the most populated cities in Ecuador, which has a population of 15.492.264 inhabitants (2012). Ecuador has a very good performance and is in the group of countries with the highest growth rate of South America (3.7 %), registering a rate of 5. 0%. ((E.C.B), 2013)

The country has the potential to develop industries in a wide variety of sectors such as oil, domestic production of raw materials and manufactured textile, mining, among others. Most of the textile companies are located in Guayaquil, Cuenca, and Atuntaqui. This study was focused on Guayaquil, the second biggest city in this country.
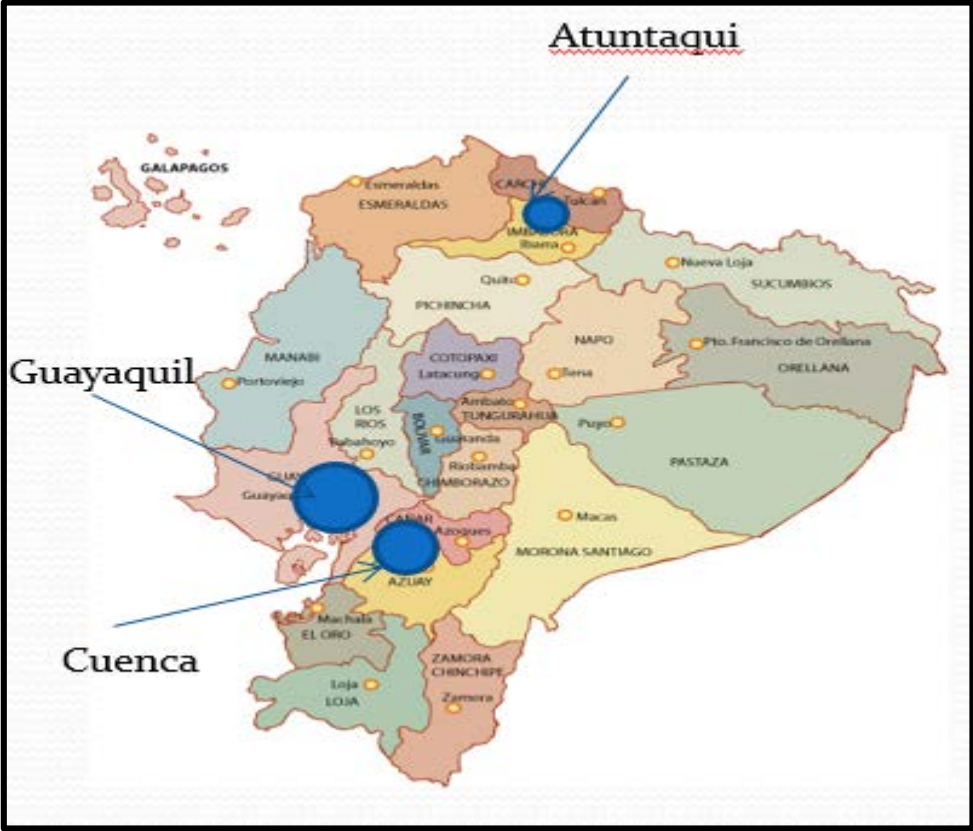
Figure 1.2. Textile Sector in Ecuador (Ecuador, October 4th, 2012),((E.C.B), 2013).

1.1.2 SWOT Analysis

One way to understand and familiarize oneself with the current condition of the small textile companies in Ecuador is through the use of strengths, weaknesses, opportunities and threats (SWOT) analysis.

Performing a SWOT analysis is critical to understanding and developing an IDEF0 model. This is because the contents of SWOT analysis are based on the considerations of research and current issues affecting companies of this sector. Meanwhile, the development

of this model will be mostly based on the outcome of the SWOT analysis, problems and other issues affecting a textile company.

From the opening of markets to the beginning of the 90's, it was thought if the textile industry did significant efforts toward improved competitiveness, this would be absorbed by the industry in neighboring countries, and especially by the powerful Colombian textile industry.

After almost 10 years since opening, reality has shown that virtually all sectors of the national textile industry, with the exception of exporting raw and the trade balance, shows a higher growth of exports over imports. Opening a motor proved important to the pursuit of regional markets. There are now several Ecuadorian companies with permanent penetration in the textile markets of Venezuela, Colombia and Peru. This has led to a technique of their marketing strategies through processes, mostly individual management training. Industrial restructuring, as a phenomenon of transformation of enterprises, has led to the specialization of the production lines, with the removal of concepts of cost center and its transformation into generating units, adding value. The specialization has reduced the internal competition for hard, small local markets, and conversely, has generated promising results in regional markets.

So given this background, we have the following:

STRENGTHS of the Ecuadorian companies in the textile sector:
• There is exporter knowledge.
• Experience and good penetration in regional markets.
• Production technology is adequate.
• Industrial restructuring.
• Machinery amortized and with their respective maintenance.
• Variety of machinery to meet the expectations of the customer.

WEAKNESSES of the Ecuadorian companies in the textile sector:

While the regional market penetration has been developed managerial and marketing skills, has highlighted the lack of centers training and industrial training for managers and machine operators.

One of the most serious difficulties that companies have faced is financial aid. It gives a disadvantage for SME textile companies compared to other companies in neighboring countries due to difficulty of obtaining fresh capital to finance the operation or renew the stock of machinery. It has been shown repeatedly that a major difficulty in the textile sector is business internal policies to seek markets abroad. It is clearly Indicated there is a "Cultural attitude" against efforts to optimize resources in the export task(Marco, June, 2010).

As the most significant deficiencies have been considered as follows:

• Lack of training programs: middle managers, operators
• Difficulty in providing raw materials and capital goods.
• Locks customs.
• The ECC (Ecuadorian Customs Corporation) fails to establish an efficient and agile   in the treatment of imports.
• High requirement of working capital: difficult access to credit and high
cost of money.
• Process technology textile finishing weak in knowledge and equipment
• Labor relations complicated. Outdated and inflexible labor codes.
• Low willingness to form business groups. There is a weak relationship between textiles and the clothing sectors.
• Lack of quality manufacturing standards.
• The smuggling and the invasion of products coming from China.

OPPORTUNITIES of the Ecuadorian in the textile sector:

The main opportunities in the textile sector have been cited as follows:

• Andean regional market very attractive: by size and benefits tariff.

• An important component of local sales are destined for the borders market.

• Similarities in culture in countries in the region.

• Ability to exploit knowledge of developed exporter.

• The international conventions help manufacturing companies export their products.

1.2   Need for Lean Manufacturing

Manufacturing companies have serious problems with their office processes or production; for this reason the need for Lean Manufacturing is born. This model will enable us to achieve the satisfaction of companies toward the customers, because it is focused on delivering maximum value using the minimal resources necessary, i.e., adjusted.

The creation of this model is emphasized in the reduction of waste in processes such as these: over-production; waiting time; transport of unnecessary materials; inventory of finished products, or in the process and correction of defects.

Once the reduction of unnecessary resources is made, the company will be able to increase productive efficiency in all processes and involve the workers to participate in the concept of proposing ideas for making things better.

Small and Medium Enterprises (SME) in Ecuador, in the textile sector, are full of waste in their office and manufacturing processes. In this Dissertation, many textile companies have been visited, and it has been found the same problems in office processes, and manufacturing. An example of the office processes is shown in the following figure:
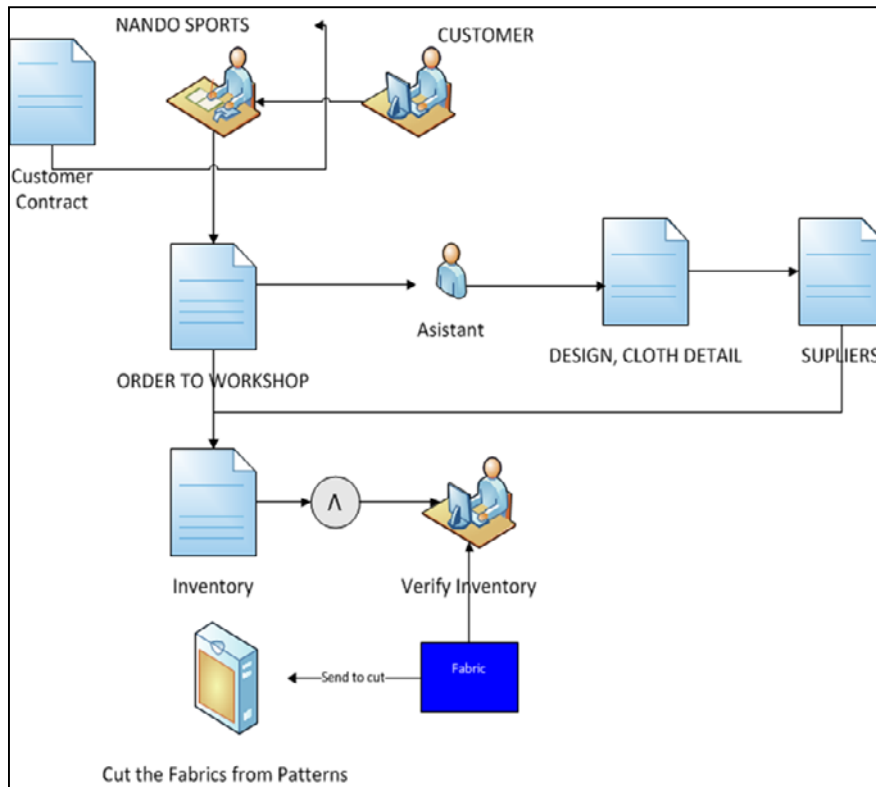
Figure 1.3. Office Operations for a typical SME´s Textile company (Hidalgo Zambrano María Gabriela, December 2012).

Its office process is not complicated, but there is a lack of documentation needed to overcome different wastes in information. Waste can also be found in their other processes for manufacturing, quality control, distribution, and inventory. An example of the manufacturing processes is the following:
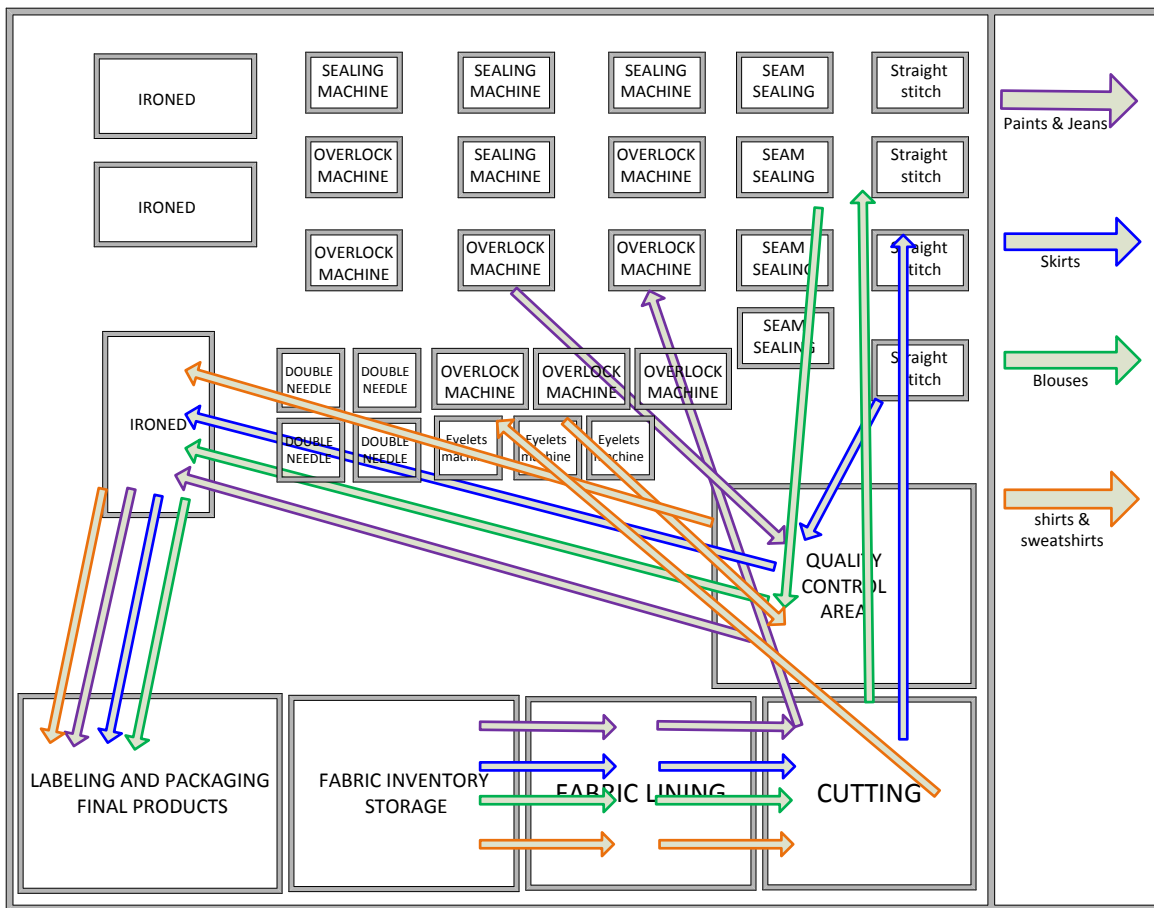
Figure 1.4. Typical Manufacturing operations for a SME´s Textile Company.(Llorenty Macías & Rodríguez Alejandro, 2014)

Medium size companies work as shown in the Figure 1.4, not avoiding different kind of wastes for the production line, work in process (WIP), movements, time, etc. In this thesis, everything will be considered to develop the model.

1.3 Thesis Strategy

Integrated Definition (IDEF) – IDEF0 function modeling method as well as Witness® simulation software, and @Risk® spreadsheet simulation software will be used to support the development of a model to enhance productivity, and transform to lean a SME´s textile companies at Ecuador.

1.4 PhD Dissertation Objectives and Specific Purposes

1.4.1 Problem Statement

Quality certification needed to get funding from national banks to minimize costs in the defects, work in process (WIP), work methods, inventories, and low productivity. This methodology is required to lean a company, design templates, develop processes, and make the correct documentation. The main goal of this Dissertation is to develop a methodology to guide the transformation of a SME´s textile company to lean manufacturing giving designing templates with processes and documentation.

1.4.2 Objectives and Methodology

Today, the IDEF0 model and methodology is an enhanced method to define and manage companies in different industrial sectors (IDEF, 2000). The objective of this dissertation is to develop a model to guide the identification and elimination of waste in an office and manufacturing environment in this sector. This model is an engineering approach to transform an office, and a manufacturing textile company from a current state to a desired future condition. This model is developed under the criterion that the lean principles can be applied to identify and remove waste in all the environments of the company (Administrative, Manufacturing and Services).

The model should integrate cultural, process and technology strategies to transform the enterprise(Underdown, 1997). It is an organized collection of activities that describes "what" must be done to change and improve the enterprise.

As a secondary objective, a field engineer's guidebook for implementing this methodology is developed to guide the transformation of the company from a current state to a lean condition with the application of the developed methodology.

The model and the lean guidebook developed in this thesis must consider the office and manufacturing environment as a whole connected and interdependent system. Literature review will be taken from international sources, and it must be robust to establish a right application of the methodology designed.

1.5 Thesis Roadmap

A roadmap is a detailed plan, or explanation, to guide you in setting standards or determining a course of action. The Dissertation plan scheme is the following:
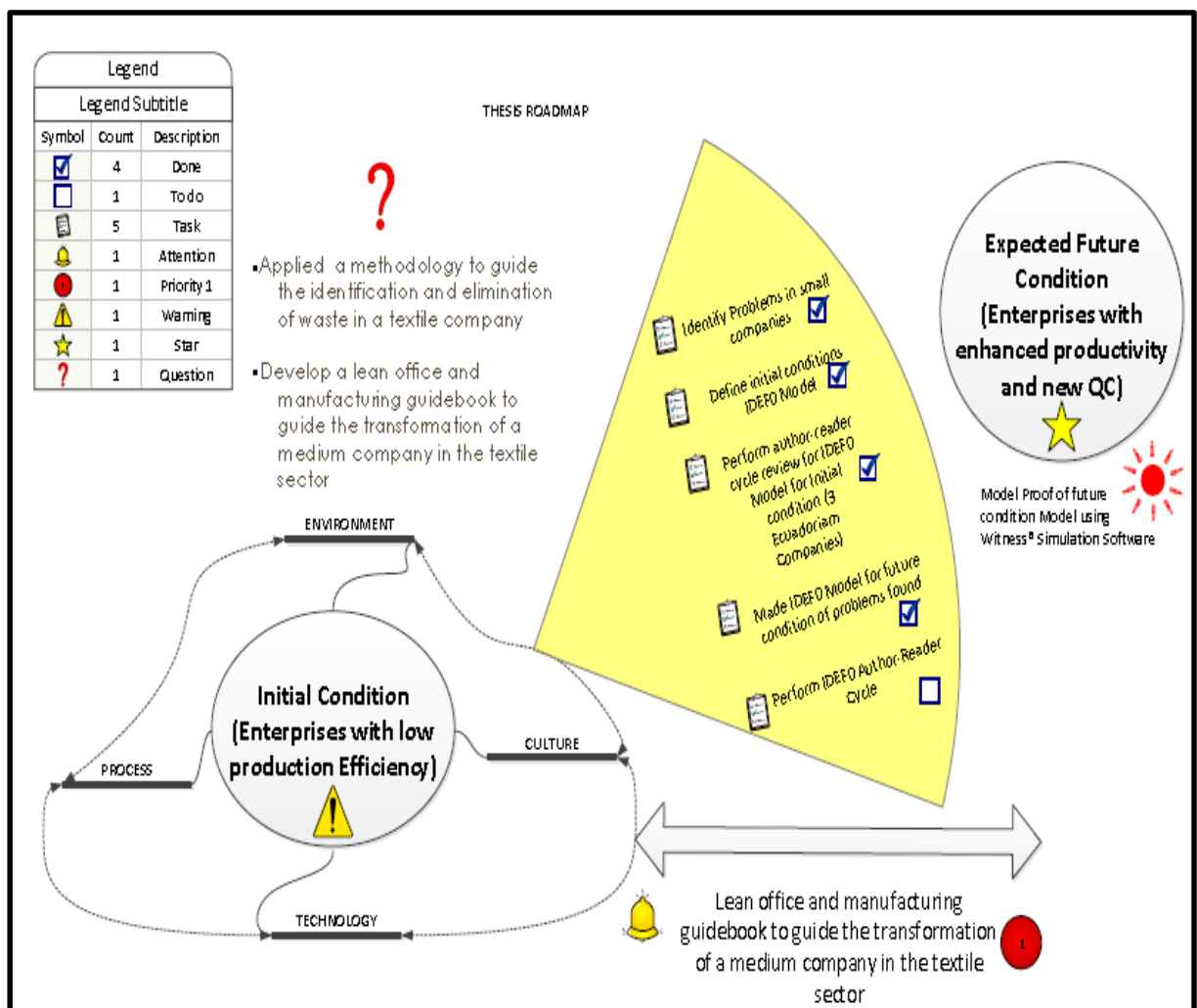
Figure 1.5. Thesis Road Map.

1.5.1 Initial Condition

From a group of textile companies in Ecuador, surveys and analysis have been conducted to determine the current situation of enterprises in terms of financial, process analysis, and the evaluation of the overall production process using Value Stream Mapping, and other lean manufacturing techniques.

1.5.2 Expected Future Condition

The expected future condition is based upon the concept of a lean Enterprise, "*A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices*"   (*Lean Enterprise Value: Insights from MIT´s lean Aerospace Initiative*, Murman Earll, Thomas Allen). With the processes identified, there will be an IDEF0 model developed to follow and understand the application of lean principles in different areas of the company (Jay, 1998).   In this model, processes and different steps of the production will be designed. After developing this model, a simulation test of the model will be performed to proof its efficiency and performance.

1.5.3   Strategy

For this thesis, the IDEF0 function modeling method is extremely useful. This model is able to define the different processes precisely, and the elements related in the office and manufacturing environment. The flexible design of the IDEF0 function modeling enables it to adapt to almost any type of environment, as the modification of the IDEF0 function modeling can be easily in order to suit different departments and systems.

1.5.4   Objectives

The objectives that are stated in the road map are required to overcome, and achieve the expected future condition. For this Thesis, the two main objectives are included as well as a guideline of the methodology that an analyst should use to transform a SME´s Textile company.

1.6 Thesis Report Organization

Chapter 1 establishes the need for a methodology for transforming an SMS enterprises to lean manufacturing, and provides background on the companies from the textile industry, given problems and making a SWOT analysis of the textile sector. The problem statement and the objective of this research are also provided. A justification of the research approach is given to clarify understanding about the method used to conduct this research.

Chapter 2 will contribute with a review of current literature concerning lean office and manufacturing. Different methods to transform enterprise will be assess in this chapter. IDEF0 is reviewed to provide a foundation for the research tasks. Simulation and other concepts are covered to provide a foundation for enterprise transformation concepts.

Chapter 3 describes the methodology that is used in this Dissertation. This methodology consists of 3 steps: Survey analysis, IDEF0 Modelling, and Simulation to proof that the changes are effective.

Chapter 4 describes the research applications and results. This chapter describes the tasks conducted in this research. In addition, the interview data is discussed and analyzed. The IDEF0 diagrams of the final methodology are provided and described in terms that are easy to understand. Finally, the brief description of the guidebook for the consultant is given.

Chapter 5 describes the final conclusions and recommendations for future research directions. A summary of the research and accomplishments are provided.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the literature concerning the application of this research, and the development of methodologies that have occurred over time to transform businesses worldwide. It will review methods used for this purpose as well as specific techniques for transforming businesses to lean enterprises.

In the first part, existing methodologies for transforming companies to lean companies are examined as well as the methods used to raise these methodologies. In the second part, different types of lean manufacturing techniques that exist, and the parameters for their business application are assessed. Simulation methodology is presented as alternative to prove that the techniques used would be effective in this study. A conclusion is made to advance to the next step, methodology used to develop this research.

2.1 IDEF0 as a tool for the design and specifications of methodologies

An IDEF0 methodology is used to improve processes as a tool for Business Process Reengineering in some enterprises (Al-Ahmari & Ridgway, 1999). A methodology can be defined as how the research questions are articulated in a particular research solving questions asked in the specific field of interest (Peter Clough, 2012). A methodology is a set of methods used for a particular research interest.

2.1.1 Business Process Reengineering (BPR) and Business Process Management (BPM)

The management theory of Business Process Reengineering (BPR) has its beginnings in 1990 with Michael Martin Hammer. He proposed a process oriented view of Business Management in which organizations should take the processes that add value to the customers minimizing the consumption of resources required for delivering their product or service (Hammer, 1990).

Companies in Ecuador are challenged to compete with foreign companies which offer better products and low prices. This has required that their operations and business processes being managed adopt a process-oriented approach as an activity or group or activities that take input, and provide an output with an increase value. ISO 9000 is beginning to be applied in textile companies. A process can be defined as "an inherently distributed system: its activities are performed by various employees, on different locations, using a heterogeneous set of IT systems" (Smirnov, Reijers, Weske, & Nugteren, 2012) consist of "logically related tasks performed to achieve a defined business outcome" (Davenport & Short, 1990) p #4; they have a specific order, an explicit beginning and an end, and the inputs and outputs are clearly identified (Davenport, 1993). See Figure 2.1.
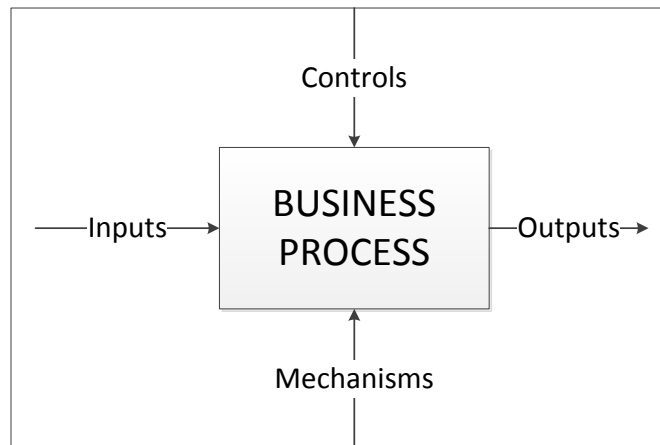
Figure 2.1. Business Process Representation

The concept of Business Process Reengineering (BPR) involves innovation, as defined by (Hammer, 1990) is "the fundamental rethinking and radical redesign of core business processes to achieve dramatic improvements in critical performance measures such as quality, cost, and cycle time". Reengineering in a company is "tossing aside old systems and starting over. It involves going back to the beginning and inventing a better way of doing work" (Michael Hammer 2003).

According to Hammer, the idea is to achieve breakthroughs in quality, responsiveness, flexibility, and cost to compete more effectively and efficiently in a chosen market. It means obliterate what you have now and start from scratch. Transform every aspect of your organization to this level (Hammer, 1990).

The main steps to this methodology are the following (Hammer, 1990):

- Organize around outcomes, not tasks.
- Have those who use the output of the process perform the process.
- Subsume information-processing work into the real work that produces the information.
- Treat geographically dispersed resources as though they were centralized.
- Link parallel activities instead of integrating their results.
- Put decision points where the work is performed and build controls into the process.
- Capture information once and at the source.

Business Process Management (BPM) is a "management through processes method which helps to improve the company´s performance in a more and more complex and ever-changing environment" (Thiault, 2011). It means that the process has to be understandable, as well as the management and governance. Then, three steps are accomplished when implemented BPM, when the process approach is fully understood, Steered, and the active process governance is integrated (Thiault, 2011).

Key differences are distinguished between BPR and BPM. Aspects as level of change, time taken from implementation, etc., are shown in the following table (Alagse, 2013):

Marked difference between BPR and BPM		
Aspect	**BPR**	**BPM**
Level of change	Radical, one step change	Evolutionary & continuous
Time taken for implementation	Long	Short time and smooth takeover
Starting point	Drawing board	Current processes and automation levels
Implementation	Huge effort required for the disruptive change	Incremental
Expanse	One major process at a time	Flexible – simultaneously across one or more / small or major processes
Methodology	Redesigning of business processes	Process and decision models
Enabling technology	Primarily IT	Primarily process technology
Involvement	Business and process experts	Process experts and all related people
Risk	High	Low
Outcome	Drastic	Incremental improvement
Cultural issues	Major concern	Not much concern
Implementation stress and concern	High	Low

Table 2-1. Differences between BPR and BPM (Alagse, 2013).

These differences are used to get a better understanding of what method to apply in the company.

2.1.2 IDEF0 Methodology

The Structured Analysis and Design Technique (SADT) is a graphic notation to system description. This tool has been used in designing computer integrated manufacturing system. SADT has been applied in many areas such as computer-aided design, computer system configuration, personnel training, and some other management areas.

SADT system description is called a "model". An SADT model gives meaning about a particular system. It provides structure and precise semantics for the natural language contained in a model, organizing a natural language in a particular and unique way, and describing a system formerly beyond our ability to explain it well.

IDEF0 is a widely used technique for the structured analysis and design of systems. Its use in improving the productivity and communications in computer integrated manufacturing systems and, more recently, as a tool for business process reengineering efforts are widely documented based on SADT (Feldmann, 1998).

In December 1993, the Computer Systems Laboratory of the National Institute of Standards and Technology (NIST) released IDEFØ as a standard for Function Modeling in FIPS Publication 183. The Integration Definition Function Modeling (IDEF0) is a Federal Information Processing Standard (FIPS) based on the Air Force Wright Aeronautical Laboratories Integrated Computer- Aided Manufacturing (ICAM) Architecture, Part II, Volume IV - Function Modeling Manual (IDEF0), June 1981(IDEF, 2000). This standard describes the IDEF0 modeling language (semantics and syntax), and associated rules and techniques, for developing structured graphical representations of a system or enterprise. Use of this standard permits the construction of models comprising system functions (activities, actions, processes, and operations), functional relationships, and data (information or objects) that support systems integration.
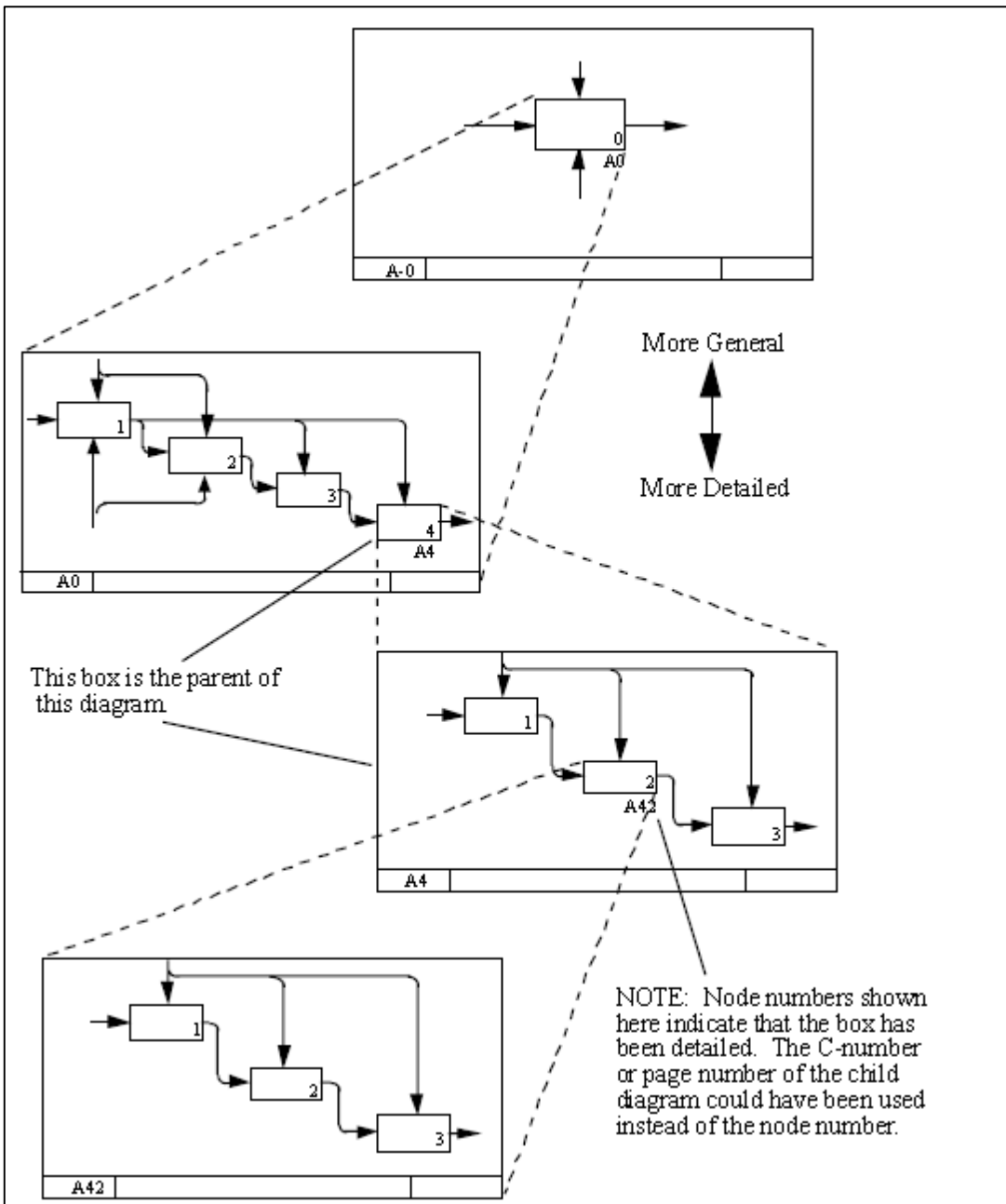
Figure 2.2. Decomposition Overview Reprinted from Information and 183 (1993).

IDEF0 models are composed of three types of information: graphic diagrams, text, and glossary. These diagram types are cross-referenced to each other (Figure 2.2). The graphic diagram in the IDEF0 model contains boxes, arrows, box/arrow interconnections and associated relationships. Boxes represent each major function of a subject. These functions are broken down or decomposed into more detailed diagrams until the subject is described at a level necessary to support the goals of a particular project. The top-level diagram in the

model provides the most general, or abstract, description of the subject represented by the model. This diagram is followed by a series of childlike diagrams providing more details about the subject.

Methodologies developed with the IDEF0 model were a combination of action, methods, and tools used together to achieve a specific purpose. Examples of these methodologies are in the office environment (Kleber Barcia, 2002) and Manufacturing environment ("Lean System Implementation," 2012), and other areas.

These methodologies were developed considering the steps needed for IDEF0 modelling, which are the following:

Interview Process: The interview is needed to gather information from someone who has the expertise considered important to develop the model. There are four types of interviews that might be conducting during the analysis phase of an IDEF project. These interviews are designed to establish the content of a current operations model, validate the Current Operations Model and to provide the foundation for a Future Operations Model, establish the content of a Future Operations Model, and the final interview referring to IDEF Author/Reader Talk Session in which the author refines the model developed.

Model development: In this state, based on the interview done, the analyst will draw as many diagrams as needed to describe the system. It would be thought as a brainstorm of the system in which many attempts to describe it are developed.

Model validation: For the model validation, the IDEF0 model has some procedures to follow, such as critiquing the model for a group of people, rules, and review procedures. The IDEF0 model requires interaction with the people involved, who worked in the System, starting the author of the model creating initial diagrams and distributing them for review and comment. Every person, who receives these diagrams should make written comments and submit them to the author. The author replies in writing and the cycle will go on until the process is complete. The results are officially accepted and validated (David A. Marca, 2006).

The IDEF0 is a well-documented methodology with a structure and easy steps to follow. When it is applied to different company models, it is easy to repeat the steps and follow the

structure, giving a greater efficiency and effectiveness (Kim & Jang, 2002; Yanlei et al., 2009).

In this case, IDEF0 is used as a top-down modelling. All the processes from the top can be described and understood as the process structure that the company should have. When analyzing a company for IDEF0, at the end it should be the best practice to analyze it with a Business Process Management Notation (BPMN) modelling. In the following graphic a decomposition of the structure of IDEF0 is shown with BPMN applications.
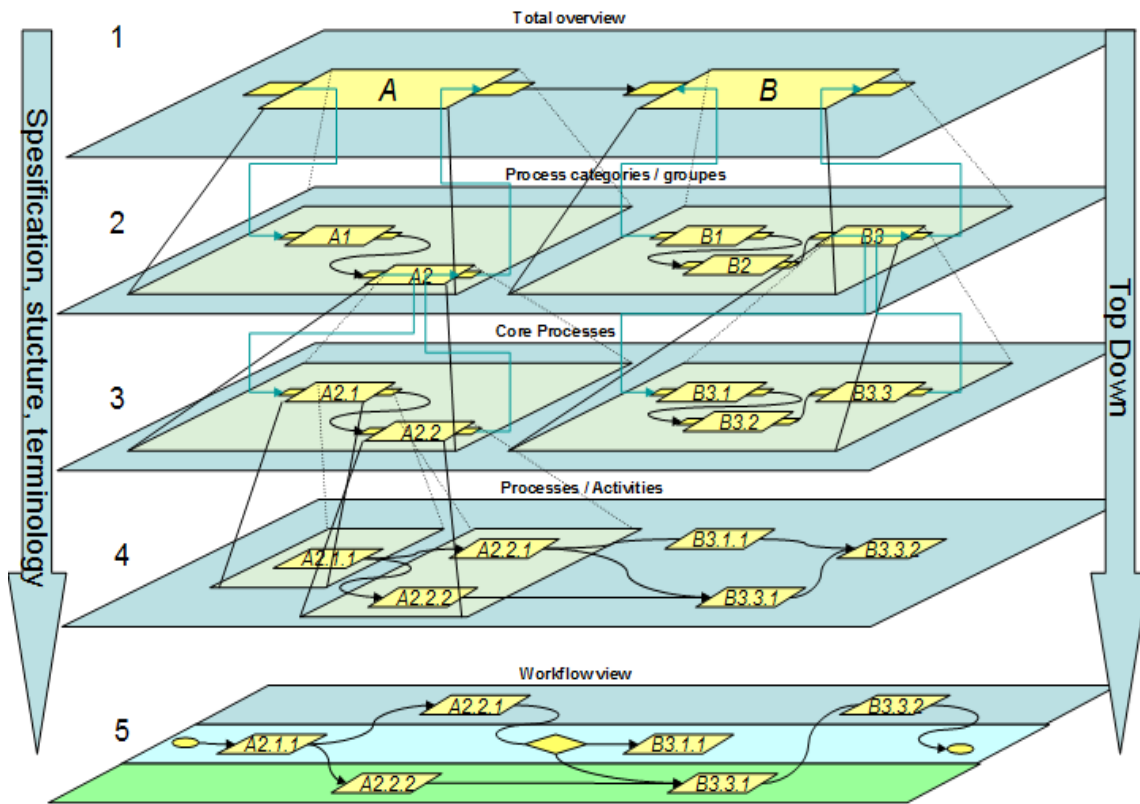
Figure 2.3. Decomposition of IDEF0 and the Workflow view or processes (eFaros, 2014).

2.2 Interview and survey as a tool to identify waste in office and manufacturing systems

The qualitative research (Kvale, 1983, page 174) interview is defined as "an interview, whose purpose is to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena". Face-to-face (FtF) interviews are the most common. Besides Face-to-Face (FtF) interviews, interviewing by telephone, and using the internet or computer mediated communication (CMC) tools are popular too.

Beside face-to-face interview and telephone interview the use of new communication forms such as e-mail and MSN messenger opens new ways for qualitative research workers for data collection. The type of interview technique chosen by the researcher can depend upon the advantages and disadvantages, which are linked to every interview technique.

A survey design provides a quantitative or numeric description of attitudes or opinions of a population by studying a sample of that population (Creswell, 2014, page155). As one form of control, researchers randomly assign individuals to groups.

The survey is used to identify specific information about a particular issue. To design a survey, it is needed the following steps(Glasow, 2005):

- Identify the purpose of survey research.
- Indicate why a survey is the preferred type of data collection procedure for the study.
- Indicate why a survey will be cross sectional.
- Specify the form of data collection.

According to Glasow (2005), a survey research is used to answer questions that have been raised, to solve problems that have been posed or observed, to assess needs and set goals, to determine whether or not specific objectives have been met, to establish base lines against which future comparisons can be made, to analyze trends across time, and generally, to describe what exists, in what amount, and in what context. In this description, a survey can be used to identify waste and other no-value added activities from the office and manufacturing.

O'Leary (2010) divides interviews into three categories: structured, semi-structured, and unstructured. Structured interviews contain a specific set of pre-defined questions that need to be answered by respondents. Semi-structured questions, on the other hand, contain specific questions, but at the same time, additional questions might be asked depending on the previous answer in order to clarify some points. Unstructured interviews are fundamentally different in a way that the numbers and wording of questions will not be pre-defined and questions will be asked according to circumstances. In the case of being utilized to transform a company, the best way to use it is with structured interviews which would contain some pre-defined questions in which different kind of waste should be identified.

Although, face-to-face interviews are time consuming, it should be the best way to get data from SMEs companies in Ecuador. Comprehensively detailed primary data about culture, technology, process, and environment can be immediately analyzed. With this method, the information obtained is detailed and rich, and the additional advantage of it is immediacy of its data validation.

The interview may be used as a quantitative collection tool; however, it is mostly a qualitative device. Information, including facts that can be checked, points of view, analyses and opinions should be clearly distinguished.

2.3 Simulation of traditional office process

The application of Lean Manufacturing concepts outside the manufacturing environment is new, and they are being applied in the last decade. Generally, 70% of the labor cost is attributed to activities that are outside the manufacturing environment, such as entering a customer order, generating an invoice, creating an engineering drawing, being admitted to a hospital, filling out a medical form for an office, ordering online item, etc. Because of this, companies have taken into account not only their manufacturing processes have to be lean, but also the office.

There are currently many deals on specific training given by universities in lean offices; these are easily found on the web. These companies and universities offer training from the application of lean principles to a specific simulation process using lean concepts office.

The simulations are based on the application of lean principles in different areas of office, as in the case of the health care industry. Below is a simple application of office processes, in which the technique read the Value Stream Mapping was applied. In Figure 2.4 you can see the initial and the final Figure 2.5 (Wojtys et al., 2009).
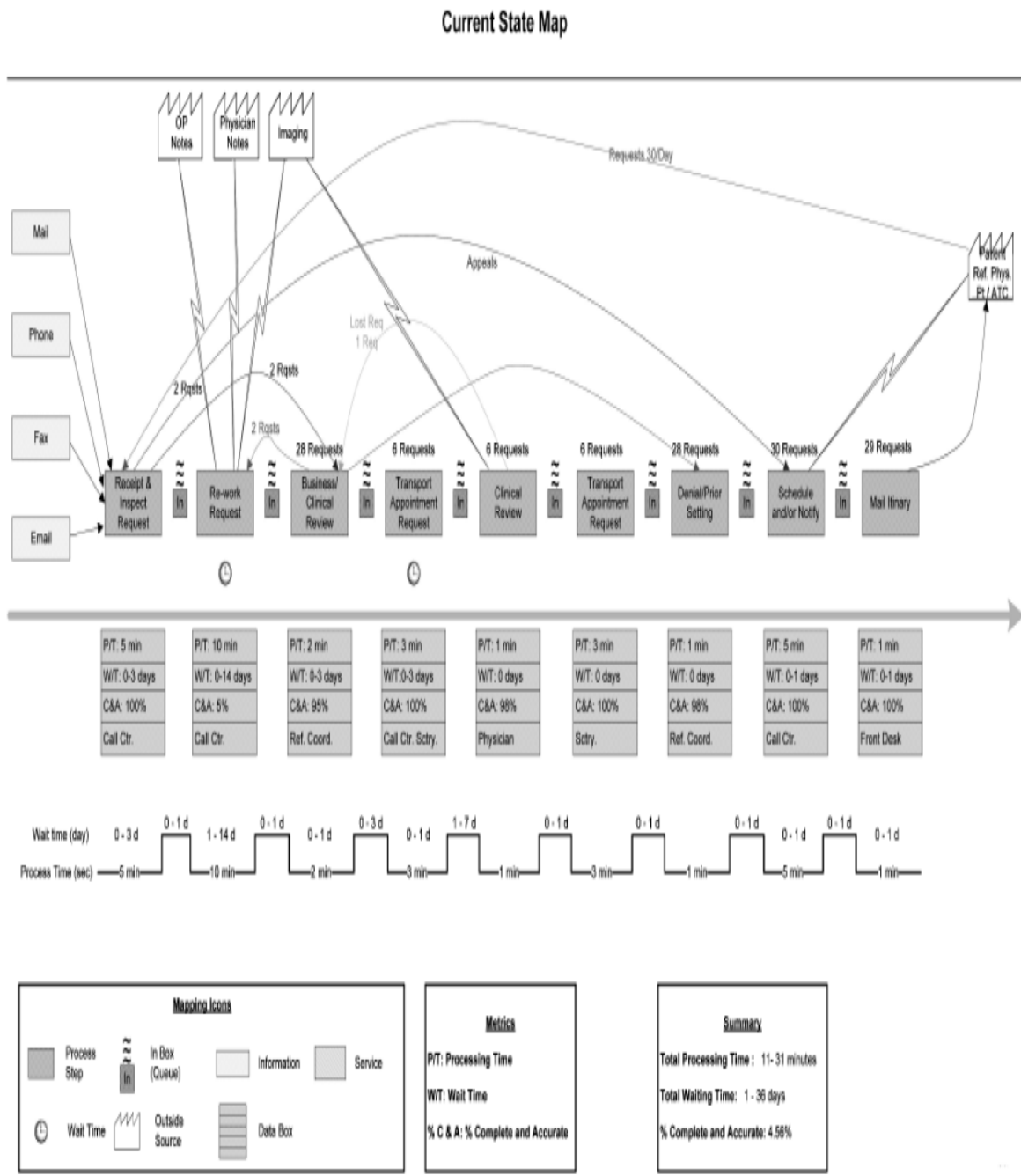
Figure 2.4. VSM before implementing Lean Manufacturing Principles (Wojtys et al., 2009).

Future State Map
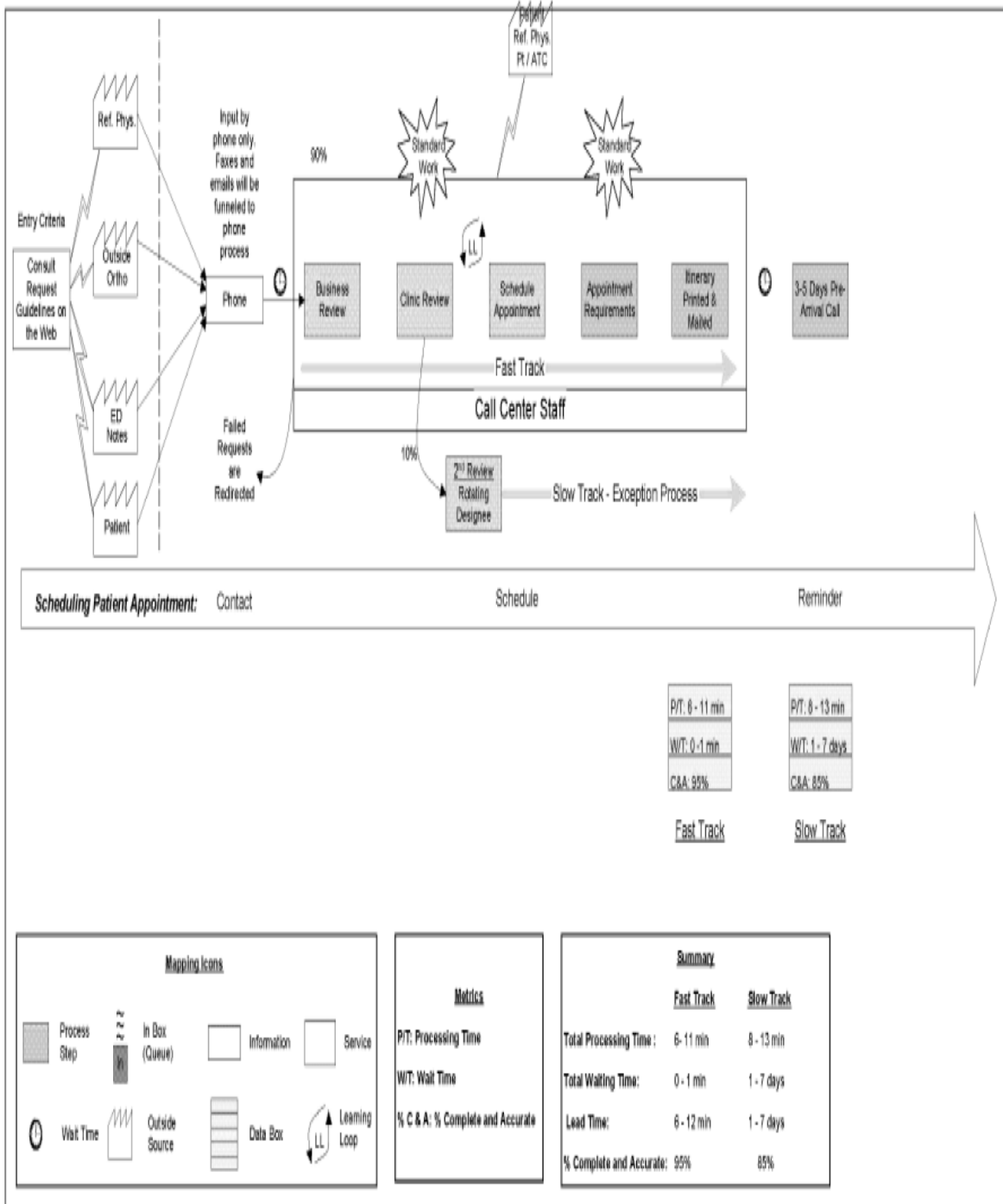
Figure 2.5. VSM after implementing Lean Manufacturing Principles (Wojtys et al., 2009).

As a result of this research, the amount of patients was improved from 70 to 89% of care for patients with a call from an average of 2.5 minutes per call. Also, it increased the number of patients, and had a significant improvement in the service provided by the health care unit.

Simulation models are being used to improve efficiency and efficacy for different kind of companies. To respond rapidly to threats and opportunities when a predictive simulation of changes is needed to reduce waste and enhance productivity (Group, 2013). With predictive simulation, a company can prove data models and variability of processes, and make changes to show its effectiveness.

2.3.1 Waste in information

There is a need to classify the waste of information in order to obtain greater efficiency in the processing and distribution of information in a firm. That is why the Lean Principles have been applied in the context of identifying the waste in information management (Hicks, 2007).

Four types of waste were identified by Hicks (2007) which is the failure to demand, demand flow, excess flow and flow flawed. The failure to demand refers to resources and activities needed to overcome the lack of information. The flow of demand has to do with the time lost to identify the different elements of information. The excess flow is due to the excessive information "not necessary" for the process. And the flawed flow includes the resources and activities required to correct the information is not accurate.

This concludes that the waste is comparable to manufacturing, given in the following table, Table 2.2:

The seven deadly wastes of Manufacturing and Information Mangement

Domain		
	Manufacturing Systems	**Information Management**	**Information Users**
1	Overproduction	Flow excess	
2	Waiting	Flow demand	
3	Extra processing	Failure demand	
4	Defects	Flawed flow	
5	Transport		Mass electronic communication
6	Inventory		Legacy databases and file archives
7	Motion		Gatekeepers/single seat licenses

Table 2.2. Seven deadly wastes of manufacturing and information management (Hicks, 2007).

Based on this Table, if there is a classification of different types of waste, it could be used to identify and remove them within the company.

2.3.2 Methodology for eliminating waste in office environment

Although the lean techniques can be equally applied to all office environments, it is clear that only automating office processes can obtain the effectiveness to reduce the defects produced by the office to zero.

The benefits of applying lean office can be summarized in the following:

1.   Improved internal communications by applying visual management
2.   Better use of space using the concept of 5S
3.   The reduction of lead times identifying and eliminating delays between departments
4.   Reducing the amount of papers to be processed using software

5.	Implementation of standard operating procedures

6.	Reducing delay times for purchasing new equipment

7.	Reducing the meetings needed to complete the work

8.	Elimination of long documents by implementing documents "on line"

These benefits can be translated into any extension to the different sizes of companies, helping to reduce the total lead times for their products ("PRODUCTION MANAGEMENT: The lean office," 2005).

Different suggestions on how to order the office and get a lean office have been given, but none of them offer the active user participation and a well-documented track the process or steps to take to achieve this goal.

In 2003, Kleber Barcia proposes a methodology to eliminate waste in the office environment. To implement this methodology IDEF0 model is used, whereby the repeatability is achieved applied to the different office environments. In Figure 2.6 you can see the steps in your application (Barcia, 2003).
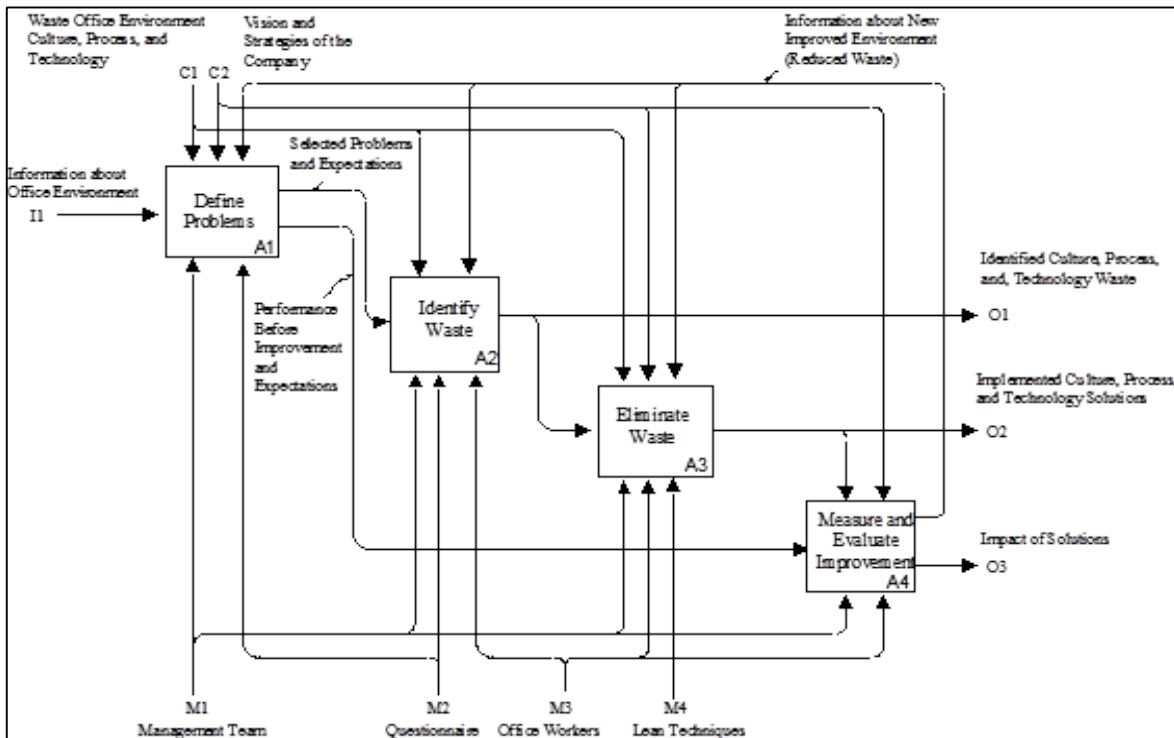
Figure 2.6. Identify and Eliminate Waste in Office Environment (Barcia, 2003).

The activities are Define Problem, Identify Waste, Eliminate Waste, and Measure and Evaluate Improvement. With the identification of the problems to be removed in the office environment and its definition, information becomes identifiable tangible problems. These problems are discussed and identified according to the methodology developed by Underdown (1997) in which culture, process, technology and environment are treated. Interactively, workers participate to the development of IDEF0 processes identifying and then eliminating waste measuring their system enhancements. This process can be applied as often as deemed possible to obtain a high efficiency. The results given in the study were measurable and encouraging.

2.4 Lean manufacturing

2.4.1 Methodology to lean a manufacturing enterprise

Any methodology to lean an enterprise always reduces waste anywhere in the company; optimizing any methodology to lean an enterprise always reduces waste anywhere in the company; optimizing core resources and establishing a corporate culture dedicated to identifying and continuously fostering customer satisfaction. The principles to transform an enterprise to lean are the following: Identifying value, eliminating waste, and generating of smooth flow (Azharul Karim, 2013). The customers create value for the organization based on needs, pricing, and timing for products or services. So, this customer information and value transformation create the value stream for the product demanded by customer. These principles guide the elimination of waste, and the simplification of all manufacturing and support processes.

Many models and techniques had been developed by researchers to design and evaluate the performance of lean, all of them evaluate manufacturing or service leanness by evaluating productivity or operational efficiency. Among these models is the model developed by the Wichita State University Department of Industrial and Manufacturing Engineering. This model describes in an effective and precise manner about how to create a lean system in an enterprise. Inputs, Outputs, Controls and Mechanism (ICOM´s) are explained in its web page lavishly.

The Figures 2.7, and 2.8 describes this model using IDEF0 methodology, showing the ICOM´s of the each activity and explained extensively the relationship among activities in its glossary of its web page. (Engineering, 2013)
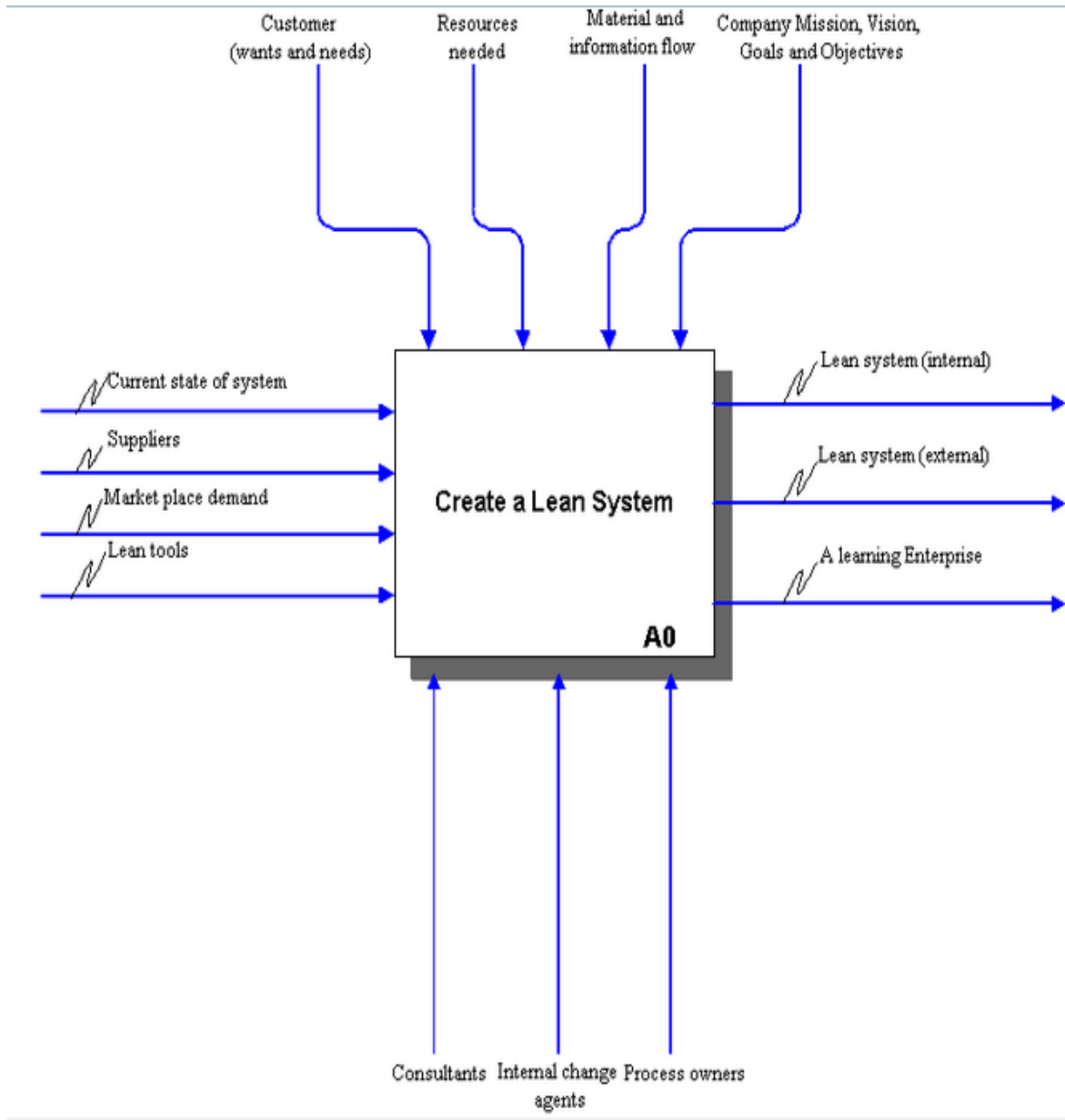
Figure 2.7. A-0 Lean activity model (model)("Lean System Implementation," 2012).
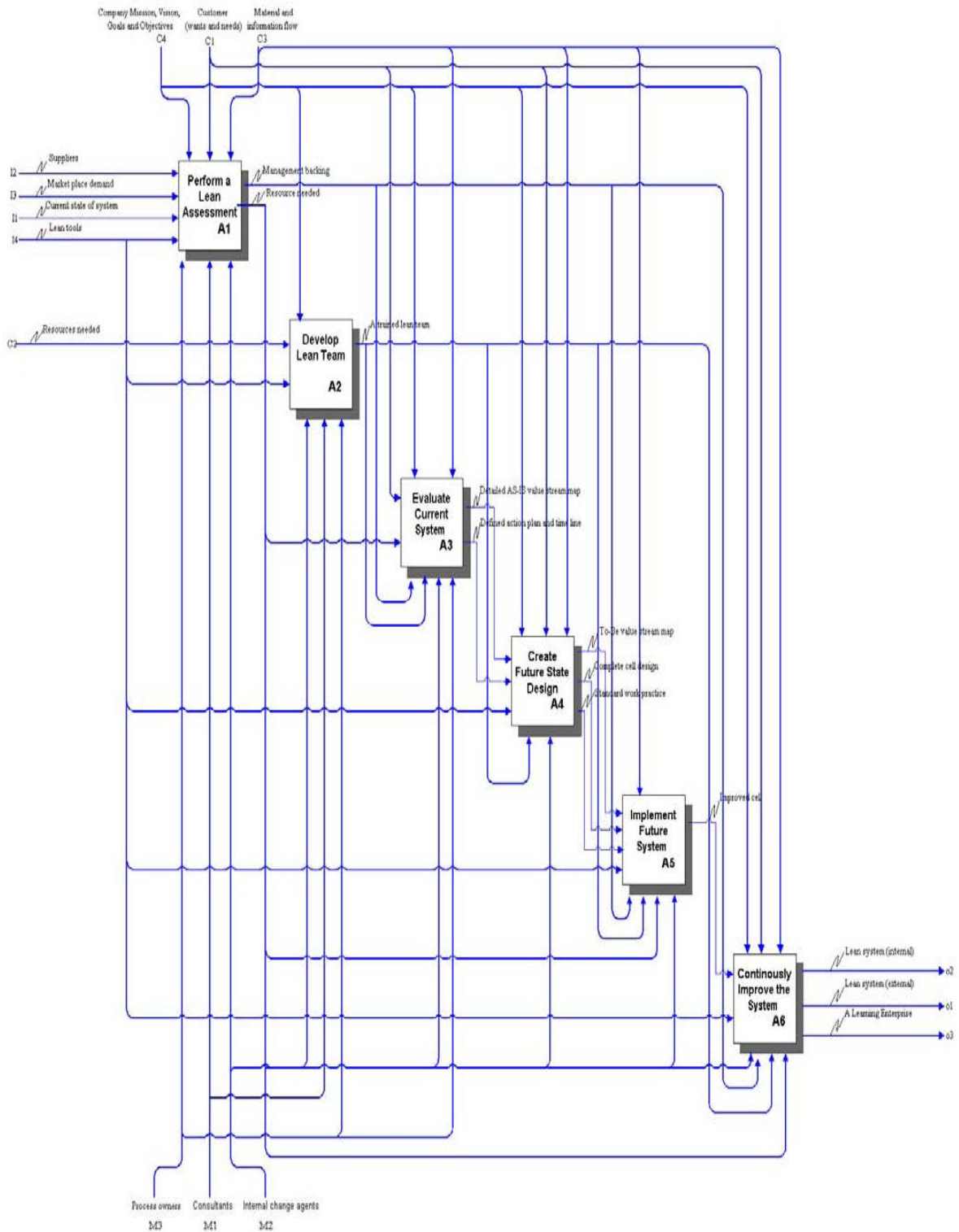
Figure 2.8.   A0 Lean system implementation activities ("Lean System Implementation," 2012).

Although the models has been well applied in different case studies in enterprises, sometimes an incorrect application of lean strategies results in inefficiencies of an organization's resources and reduced employee confidence in lean strategies. The success of any strategy depends upon organizational characteristics, which implies that all organizations should not or cannot implement a similar set of strategies in their particular case (Shah & Ward, 2007).

It is crucial to measure the performance to realize the benefits of lean practices. Many models and techniques have been developed by researchers to evaluate the performance of lean. Most of the researchers measured manufacturing leanness by evaluating productivity or operational efficiency.

This Dissertation is intended to apply lean principles in a different manner, following three simple steps, that is, interviews, IDEF0 modeling, and simulation. With these steps, finding solutions with a kind of "muda," or waste, is to be found.

- To cope with specific threats to the business – usually associated with poor relations with the customer base, or a particular customer, and low productivity because of culture, process, technology, and environment problems.
- Quality of product or delivery problems
- Requirement to reduce cycle time from order to delivery
- Launching and delivering new products or services
- Developing best value.

Waste elimination process found in this research is related to the lean techniques developed by Toyota after World War II by modifying Ford's mass production system to meet the specific needs of the Japanese market at that time.

In the Figure 2.9, all the lean principles are displayed. Principles well known, such as Just-in-time, Jidoka, Heijunka, visual management, are shown.
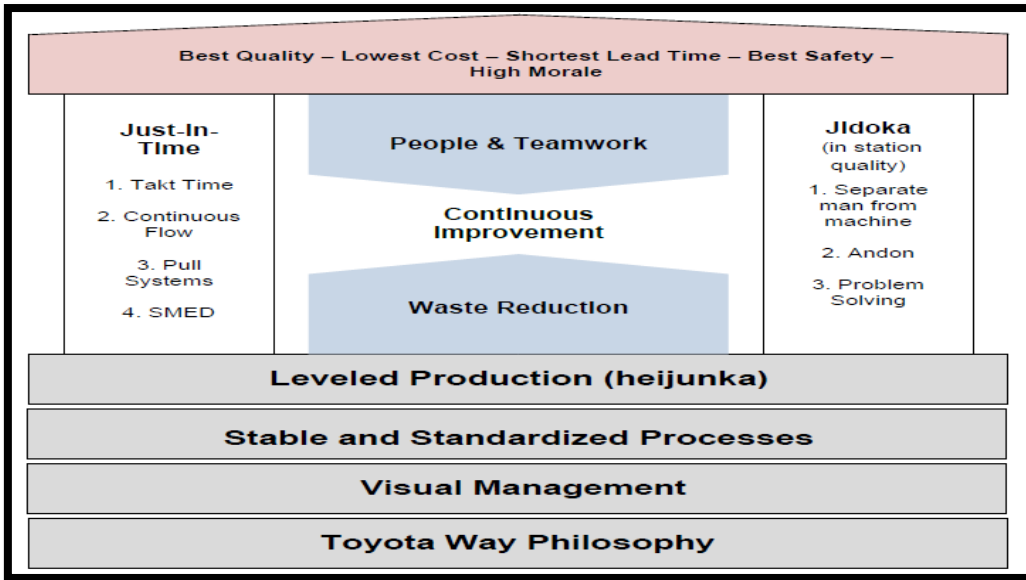
Figure 2.9. Lean Principles (Stump, 2008).

One of the principles applied in this Dissertation is the Waste Reduction. Waste reduction is an important component of the Toyota house, and implies that waste excess across the company must be eliminated. Three kind of waste are displayed in the Figure 2.10 (*muda*, *Mura, and muri*) these wastes are aimed to be eliminated in the methodology made in this dissertation. .
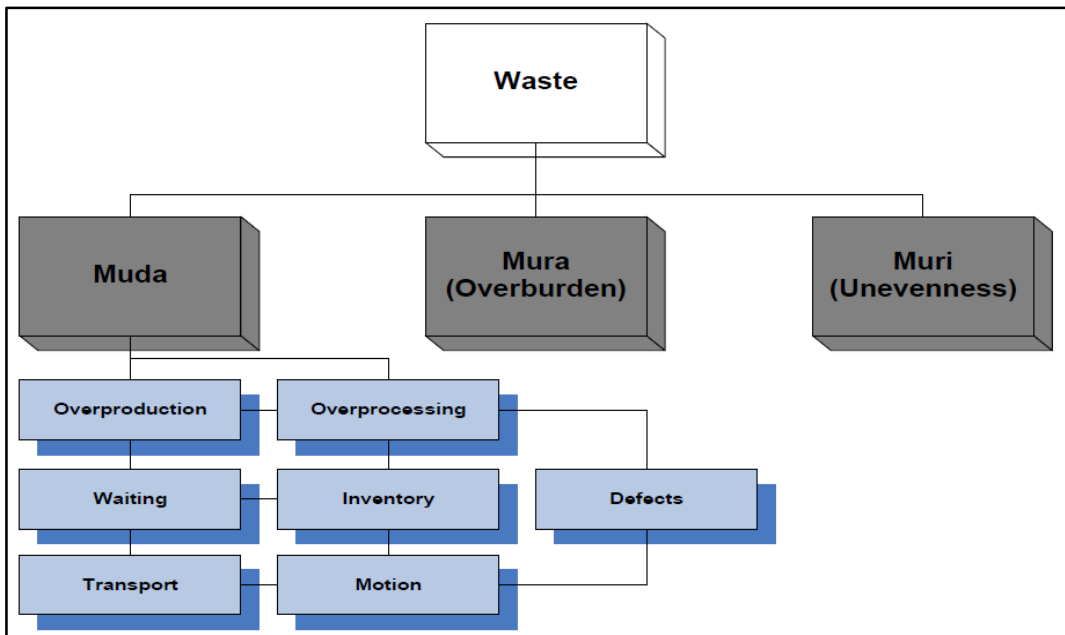
Figure 2.10. Waste (Muda, Mura and Muri) (Stump, 2008).

2.4.2 Simulation as a tool to prove a methodology

Simulation in general is focused on steady state performance of models. Modern simulation methodologies and software tools are specifically designed to limit transient effects on measurements. Predictive simulation modeling can be used to prove that a methodology is effective (Gahagan, 2008; Group, 2013).

Simulation, through the use of simulation software, creates statistically accurate models to represent the behavior of real life systems in order to subject them to predictive experimentation. Different scenarios can be proved by implementing solutions to the initial model validated in the enterprise. The advantage of using this software is that many questions can be answered without making a disturbance in the real life system.

Simulation has gained importance in the past few years and allows designers to imagine new systems and enable them both to quantify and observe behavior. Whether the system is a production line, an operating room or an emergency-response system, simulation can be used to study and compare alternative designs or to troubleshoot existing systems. Simulation models show statistical results of a real life system proving that the assumptions done for the system are correct.

Several researchers in enterprises and journals have studied performance of a real life system using simulation techniques. In this dissertation, simulation will be used to prove that the changes needed in a particular system would be effective through eliminating waste and implementing a documentation process in the enterprise developing IDEF0 modeling technique. Thus, the user of the model conducts experiments on the model with a view to understanding what would happen in the real system; this being the one that the model is intended to represent, whether it actually exists making a scenario analysis or not.

2.5 Conclusion of literature review

To support the steps made in this methodology/Dissertation, which are interviews, and surveys to identify and eliminate waste in office and manufacturing environments, IDEF0 methodology to define processes and documentation needed for the company to move

forward to a lean state, and simulation modeling to prove that the changes needed to transform the company would actually work for.

For this purpose, although lean manufacturing has been used extensively in the manufacturing environment, using the lean philosophy in the office environment to get a better model to exceed the expectations is also needed.

Although many methodologies have been used to change enterprises to lean, in this dissertation three steps are needed for the transformation of a SME´s to a lean enterprise in the textile company; these are the following:

1.   Lean implementation for documentation

In this step, waste must be eliminated in the company. A proposed model using IDEF0 methodology is designed in order to get a better understanding of the company. In this model, documentation, such as procedure manual, work instructions, records, templates for quotation, orders, suppliers, production orders a lean information management system, is designed.

2.   Lean implementation for production system

A process approach using IDEF0 is employed in this step too. All the documentation to lean the production system is designed.   A documentation system to link office (administrative) and production is proposed. Templates, orders, manuals, work instructions, records are designed too.

3.   Simulation Analysis using Witness® Software and spreadsheet simulation modeling

Simulation modeling is a valid tool to evaluate changes to be implemented in a SME´s. A model is constructed and validated to show that the real system would enhance productivity if the best scenario is applied. Statistical analysis as well a graphical representation of the "real world" is presented in this dissertation.

CHAPTER 3

METHOD

3.1. Principles

3.1.1. Research Method

The research method used is the survey because it can get relevant information through the types of survey recommended: interview, and questionnaire.

The interview was conducted in 4 SMS´s companies, in which the design of the questions was about different topics, (Barcia, 2003; Martin, 1995) such as:
- The culture
- Processes
- Technology
- Environment

The questions made were opened, close ended, and so, the worker can delve into the various problems facing the company. Once all of the information relevant to the problems of the company is collected, an exhaustive examination was made. Thus, the classification of the waste with the owner´s expectations, main processes, documentation, and lean techniques to be used in the company will give a guide to make improvements needed to transform the company to lean.

With the data, and information, the processes of the company would be designed, and a simulation model of the company in Witness® would prove that improvement proposed is effective.

3.1.2. Development of the preliminary interview instrument

The Interview instrument is developed considered the SMS Company to be analyzed, types of waste, processes, and documentation. In this case, the components of the interview instrument were the following:

- 13 questions to aid in the identification of waste in the **culture area** in office processes - Manufacturing
- 23 questions to aid in the identification of waste in the **process area** in office processes - Manufacturing

- 15 questions to aid in the identification of waste in **the technology** area in office processes - Manufacturing

- 12 questions to understand the activities in the **environment** that enterprises are currently using to improve office processes – Manufacturing

In the Appendix C is shown the interview instrument used in this Dissertation, in which each component was analyzed by members of the Committee, and an expert in the field.

3.1.3 Methodology

The methodology proposed, and used in this Dissertation is represented by the following flow:
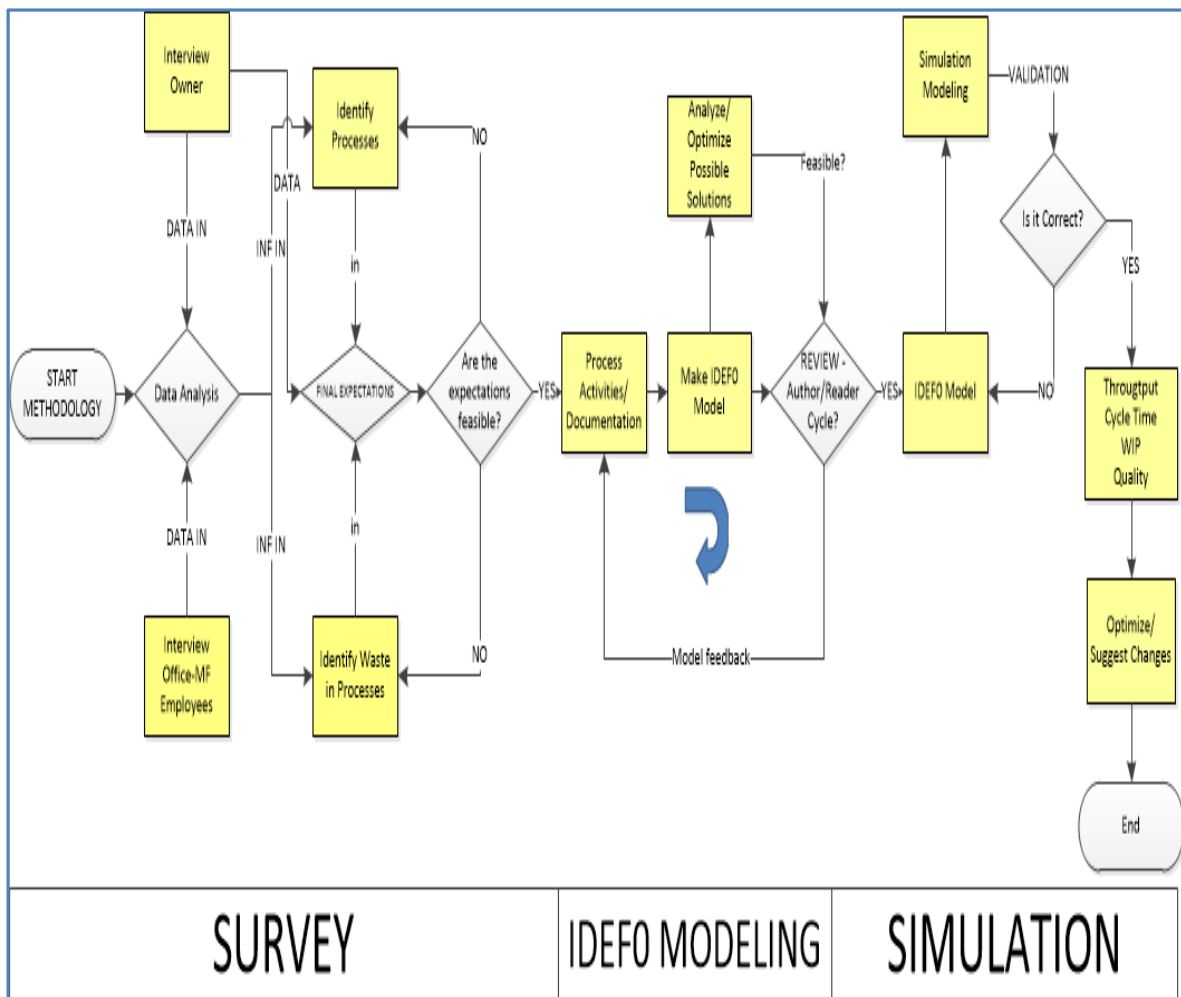
Figure 3.1. Proposed methodology for the research.

In the first part of the flow, the survey instrument is designed, and applied. Interview is conducted to the owner, office, and manufacturing employees. Waste is identified, and the

IDEF0 modeling process is developed (David A. Marca, 2006; Feldmann, 1998). Processes and documentation are identified, proposed to the company. Lean techniques are analyzed, and then a simulation model to prove that the elimination of waste is designed. This model will show to the company´s owner about the advantages of following the change besought for this methodology.

3.1.4. Research Task

The research tasks in this study were the following:

1. Designing the survey instrument to be used to the company. This survey is used to identify and eliminate waste in office – manufacturing in the company.
2. Applying IDEF0 methodology to identify processes, documentation and waste in the different departments, following BPMN principles too. A company´s model is designed presenting to the owners the advantages that the company would have if enforcing this model.
3. A simulation model is made to validate if the improvements, with the waste eliminated, include better processes and effective documentation. This model is validated with the current conditions of the company and a future model is made showing a better company in throughput, quality, WIP, and productivity.

3.2 Developing of the methodology using IDEF0 technique

In this methodology, which will be applied for SMS companies in Ecuador to enhance include identifying problems, identifying/defining processes, making IDEF0 diagrams, and analyzing possible solutions.

In the Figure 3.2, the main steps of this methodology are shown,

	Author:	Date: 22/09/2013		WORKING	READER	DATE	CONTEXT:
Used At:	Project: Research Results	Rev: 22/09/2013		DRAFT			■
				RECOMMENDED			
	Notes: 1 2 3 4 5 6 7 8 9 10			PUBLICATION			A-0

Node: A0 — Title: Transform the company into Lean — Number: — Page: 2
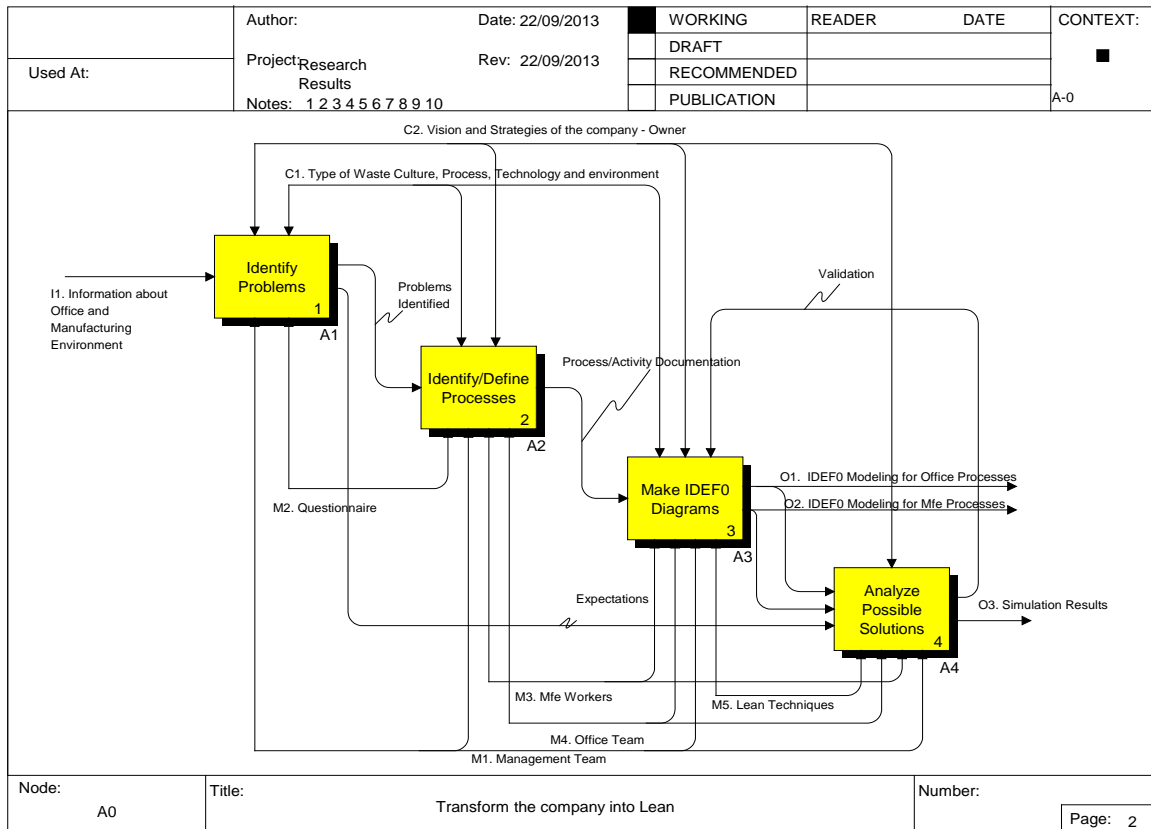
Figure 3.2. Main steps of the methodology to transform SMS companies to lean

The transformation of small and medium-sized companies to Lean Manufacturing presents a series of processes that are detailed below:

Identify Problems (A1)
Identify/Define Processes (A2)
Make IDEF0 Diagrams (A3)
Analyze Possible Solution (A4)

These steps are important for the company to implement the methodology. They already allow the identification of problems (A1) that the company has through meetings with the owner, head of production, and the office manager.   These people will identify and define processes (A2) in order to make IDEF0 Diagrams (A3) of the company, and visualize a complete picture of the company. Based on these diagrams, and waste identified in the meetings, an analysis of possible solution (A4) is done. In this analysis, any waste found is eliminated using minimal resources with high quality, achieving customer´s satisfaction.

Identified problems is divided as follows in Figure 3.3,

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			RECOMMENDED			
	Notes: 1 2 3 4 5 6 7 8 9 10		PUBLICATION			A0

C1. Type of Waste Culture, Process, Technology and environment

C2. Vision and Strategies of the company - Owner

I1. Information about Office and Manufacturing Environment

Perform interviews 1

Company Information

Perform Questionnaire 2

Surveys

Analyze Data 3

Expectations

Problems Identified

M1. Management Team

M2. Questionnaire

| Node: A1 | Title: Identify Problems | Number: |
| | | Page: 4 |

Figure 3.3. Main steps of the methodology: Process A1, Identify Problems.

To make an effective identification of problems, conducting interviews of the managers of the company, using questionnaires to identify waste, and analysis of data acquired are all necessary.

Identify/Define processes is described in Figure 3.4.

	Author:	Date: 24/09/2013		WORKING	READER	DATE	CONTEXT:
Used At:	Project: Research Results	Rev: 24/09/2013		DRAFT			
				RECOMMENDED			
	Notes: 1 2 3 4 5 6 7 8 9 10			PUBLICATION			A0

C2. Vision and Strategies of the company - Owner

C1. Type of Waste Culture, Process, Technology and environment

Problems Identified

Meet with owner **1**

General Information

Meet with Office Manager **2**

Identify of Office Processes

Meet with Production Manager **3**

Identify of Production Processes

Process/Activity Documentation

M4. Office Team

M3. Mfe Workers

M1. Management Team

M2. Questionnaire

Node: A2	Title: Identify/Define Processes	Number:
		Page: 6

Figure 3.4. Main steps of the methodology: Process A2, Identify/Define Processes.

Meetings with the owner, office manager and production manager are a success key to identify/Define processes. With these people, all the processes would be identified and defined in a structured manner.

Making IDEF0 diagrams for the company is the following step to transform a SME company to lean. This point allows the author to have a global vision of the processes within the company. The IDEF0 tool brings all the explanatory information about each process (Figure 3.5).
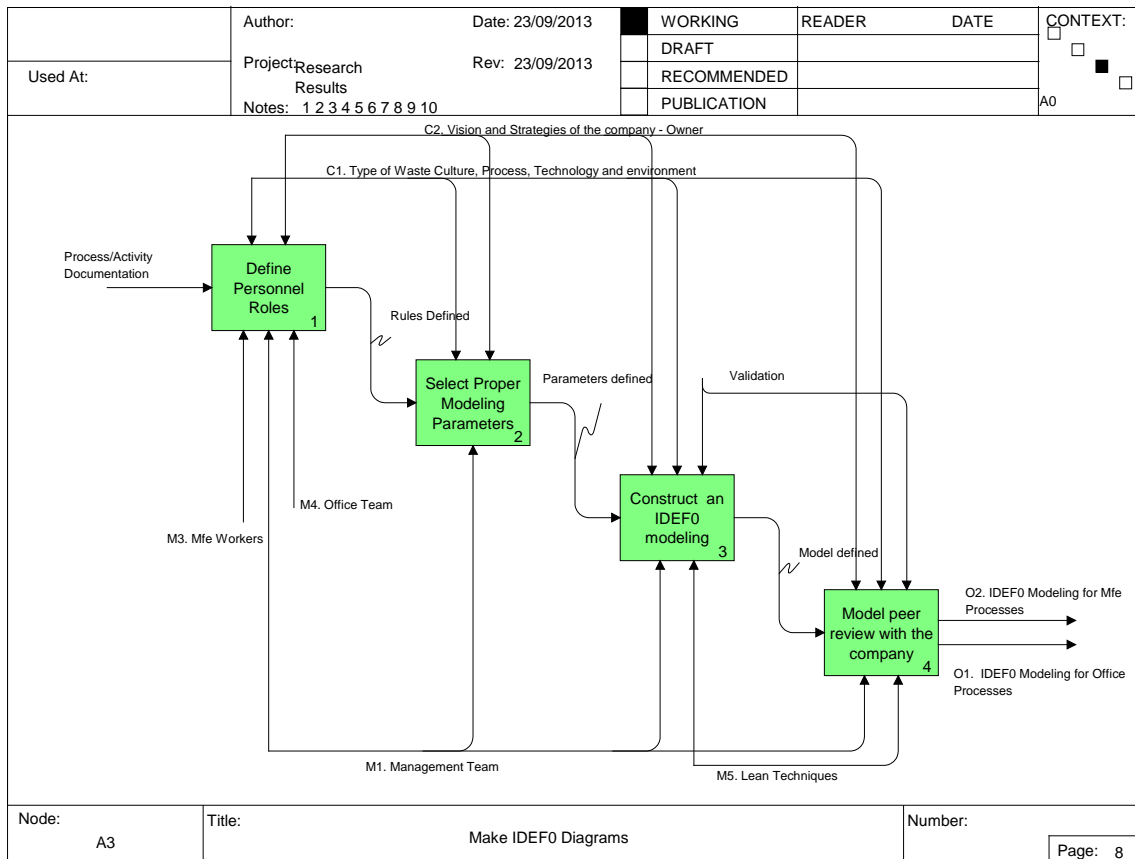
Figure 3.5. Main steps of the methodology: Process A3, Make IDEF0 Diagrams.

The steps to follow are defining personnel roles (A31) which will allow the author to identify the important points of the IDEF0 Model; select proper modeling parameters (A32) where it is broadly defined, the objective of the model for well constructing (Authoring) an IDEF0 Modeling (A33) with the purpose of Modeling peer review with the company (A34) in order to be able to use it properly.

Finishing the IDEF0 diagrams, the analysis of possible solutions (A4) must be done (Figure 3.6).

	Author:	Date: 23/09/2013		WORKING	READER	DATE	CONTEXT:
			■	DRAFT			
Used At:	Project: Research Results	Rev: 23/09/2013		RECOMMENDED			
	Notes: 1 2 3 4 5 6 7 8 9 10			PUBLICATION			A0

Node: A4	Title: Analyze Possible Solutions	Number:
		Page: 10
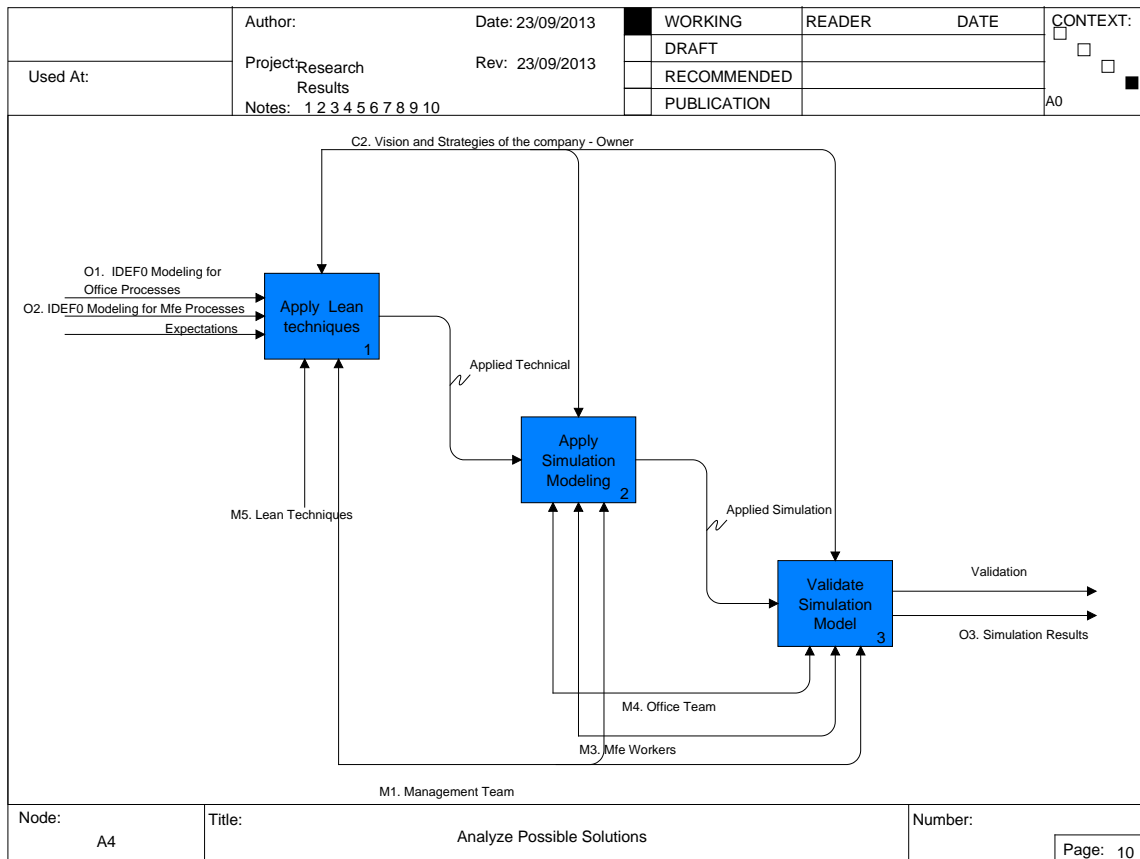
Figure 3.6. Main steps of the methodology: Process A4, Analyze Possible Solutions.

At this point, applying Lean Techniques (A41) will allow the company to implement adequate techniques to achieve quality and productivity. A simulation model (Apply Simulation Modeling (A42)) will determine if the techniques applied are ideal for the company in order to eliminate the waste and finally transform this SME company to Lean. To prove that are these changes are effective, a validation of the model designed is required [Validate Simulation Model (A43)]. At the end, the simulation results would show the owner and managers if the implementation of the documentation, processes, etc., is effective.

3.3 Lean Manufacturing Guidebook

The following image shows the guide that was used to implement Lean manufacturing technique:
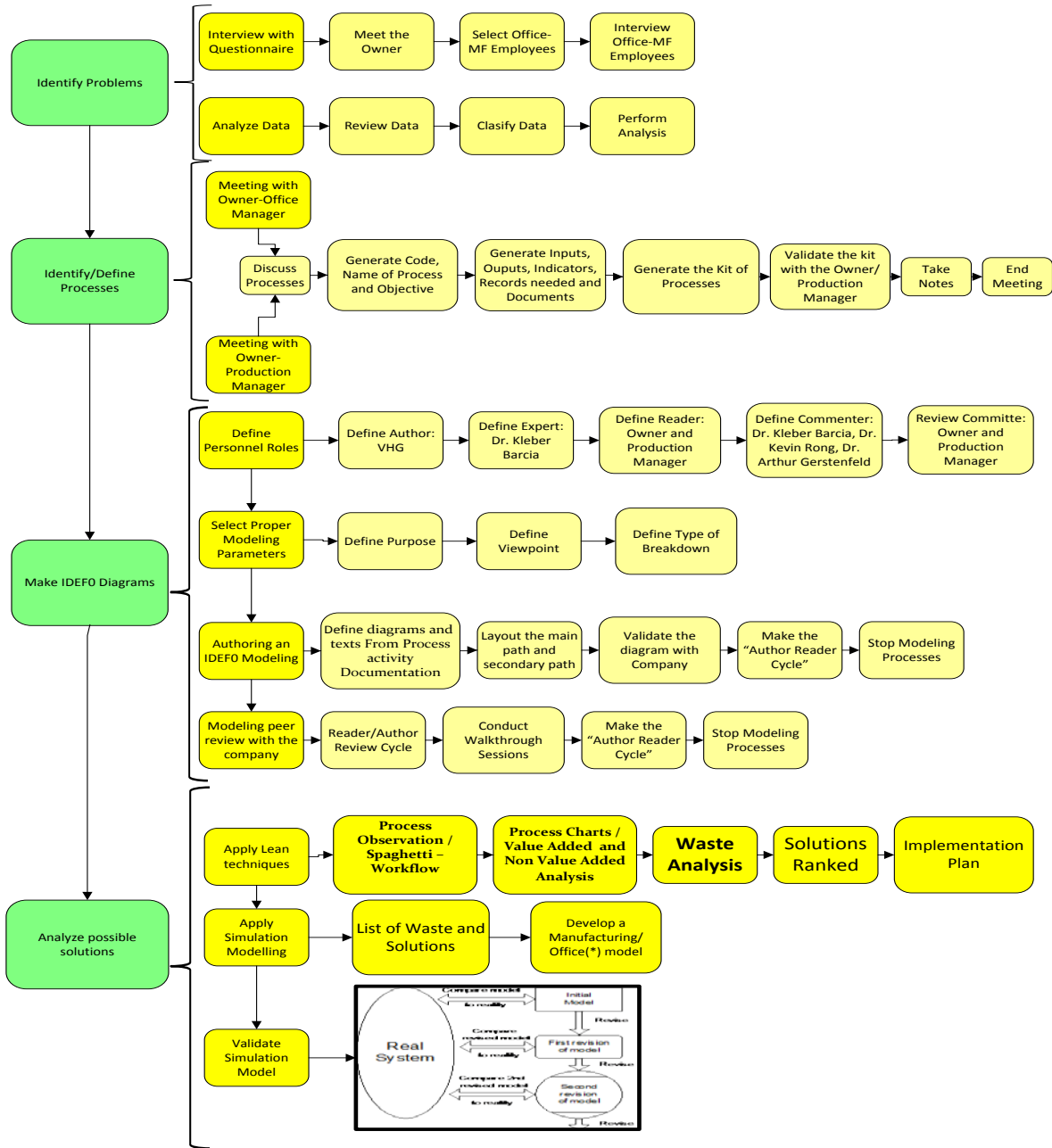
Figure 3.7. Main steps of the lean manufacturing guidebook.

A guidebook for consultants is developed in Appendix A. In that guidebook, all the steps to follow to transform a SME company are shown in more detail.

CHAPTER 4

RESEARCH – RESULTS

In this chapter, a pilot case study is shown. In this case study, an extensively use of the methodology was applied. The main parts of the methodology as the description of the company, surveys, IDEF0 methodology applied to this SMS Company as well as the final simulation is shown.

4.1 Pilot Case Study

4.1.1 Company Background

The company selected was a garment company. It was started in 1998. It has 14 years of experience, and currently has 75 permanent employees and 60 machines. It has clients like IASA Caterpillar and Interagua.

The company manufactures the following products (Figure 4.1):
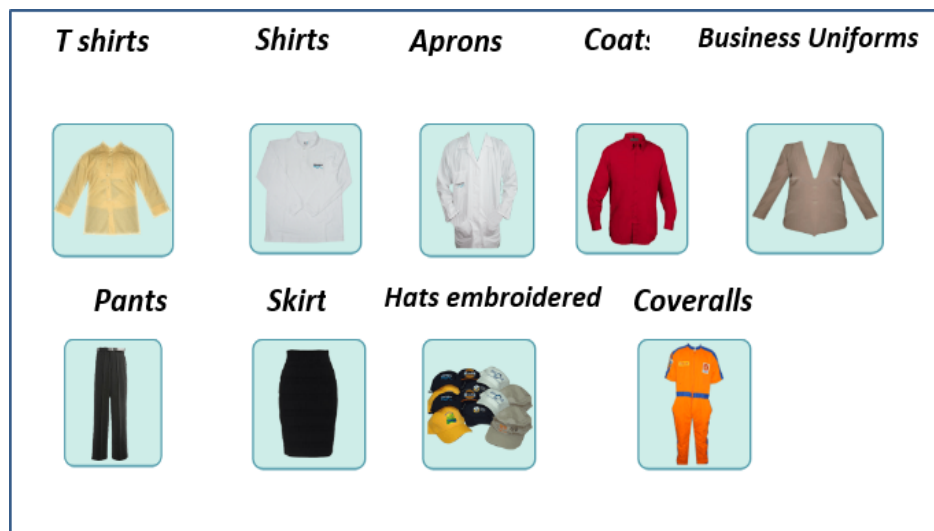
Figure 4.1. Products of a pilot SMS company

4.1.2 Interview

Interview with the company´s owner

An interview was conducted with the owner, and some final expectations were determined. These expectations were focused in the office and manufacturing processes. These are shown in the Table 4.1.

Metrics	Before Improvement	Expectations	After Improvement	Impact	
Throughput	Quotations/Day	Increase %			
Cycle Time	hrs/Quotation	Reduce %			
Work in Process	Quotation in 1 Workday	Reduce %			
Quality	Quotations/Day are Rejected	Improve %			

Metrics	Before Improvement	Expectations	After Improvement	Impact	
Throughput	units/Day	Increase %			
Cycle Time	min/unit	Reduce %			
Work in Process	units in 1 Workday	Reduce %			
Quality	units/Day are Rejected	Improve %			

Table 4.1. Final expectations taken from the owners of the company, taken from Barcia (2003).

Throughput, cycle time, work in process, and quality are the main concerns of the owner about his company. He wants to improve the four metrics to a minimum of 30 %.

Throughput is the units produced by a time unit, cycle time is the time that the product uses to finish all its operations, WIP is the material stored among the operations, and quality is the amount of defects produced not only in the office, but also in the production processes.

Interviews Office Employees

Designing the Questionnaire

The questions were prepared based on an analysis of the potential waste of the company. Here is a list of different topics and possible waste (Barcia "PRODUCTION MANAGEMENT: The lean office," 2005) 2003; Boardman & Johnson, July 2001; Glasow, 2005; Martin, 1995):

- o Culture
  - People
  - Processing
  - Defect
  - Waiting
  - Environmental
- o Process
  - People
  - Overproduction
  - Processing
  - Waiting
  - Inventory
  - Motion
  - Transportation
  - Environmental
- o Technology
  - People
  - Processing
  - Waiting
  - Inventory
  - Environmental
- o Environmental
  - People
  - Processing
  - Defect
  - Waiting
  - Overproduction
  - WIP Inventory
  - Transportation

The possible causes of waste office process are long process set-up, an unbalanced workload, early preparation reports, etc.   Fifty-five causes were identify by Barcia K., in a study done in US companies in 2003. These causes were used to develop the preliminary interview instrument. This instrument was checked with the owner´s expectations, validated, and applied.

Fifty-five causes have been identified (Barcia K. 2003) in a study done in US companies in 2003:

Causes Of Office Process Waste
Long Process Set-Up.
Unbalanced Workload.
Early preparation of reports.
Existence of irrelevant data.
Files piled up between work desks.
Documents waiting to be matched or signed.

Large file storage area.
Copier is too far from desk.
Paper and stapler kept away from printer and copier.
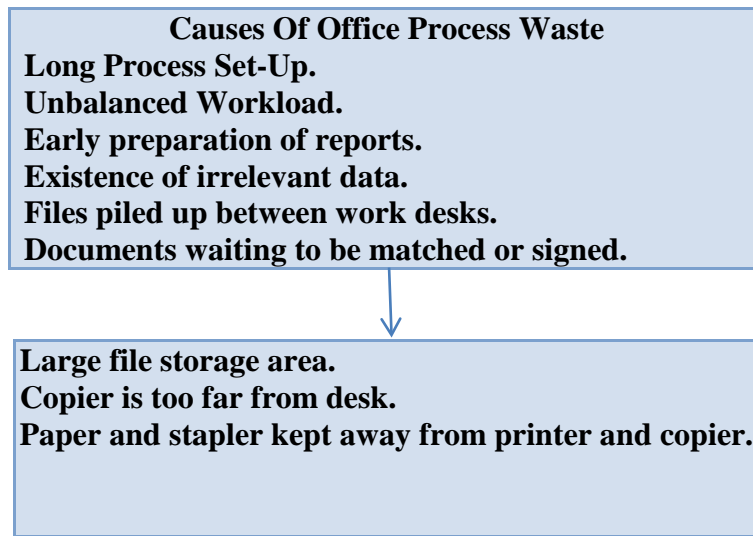
Figure 4.2. Causes of office process waste. PhD Dissertation, Kleber Barcia V., 2003 (Barcia, 2003).

The following images represent a part detail of the questionnaire used for the interview with office employees:

OFFICE AREA

1. What is your job title?

_____

2. What are your responsibilities and duties in this company?

_____

General Information

3. How long have you worked for this company?

_____

4. How long have you held your current position?

_____

5. What actions has the company taken to improve the employee skills?

____ Employee Assessment   ____ Goal Setting

____ Employee Education Programs   ____ Performance Appraisals

6. What actions has your company taken to build trust between employees and management?

____ Capability trust   ____ Contractual trust

____ Communication trust   ____ Others

Culture Waste - Processing

7. What actions to build trust would you do differently if you could d

_____

8. What actions has the company taken to improve communication?

____ Improve the Environment   ____ Delegate

____ Open Communication   ____ Others

9. What actions to improve communication would you do differently if you could do it again?

_____

10. How is the communication between staff working in your company?

____ Excellent   ____ Good

____ Deficient   ____ Bad

11. Do you think that communication at the company is the best?

____ Yes   ____ No   ____ Maybe

12. Are all directions given by the production managers supervisor to the employees clear and understandable?

___ Completely clear   ___ Moderated clear

___ Low clear   ___ Not clear

Culture - Defect

13. Do they communicate in time any changes in production process?

___ Always   ___ Usually
___ Sometimes   ___ Never

14. Are the orders, always informed personally or use some other means?

___ Personally   ___ Other means

15. What is the Objective of the company?

___ Quality Standards   ___ Efficiency and Cost

___ Profit Maximization   ___ Safety

16. Are all company employees knowledgeable and focused on the same goal?

___ Completely focused   ___ Moderately focused

___ Low focused   ___ Not focused

17. Do you think you will get the Desired Objectives with the implemented system?

___ Yes   ___ No   ___ Maybe

18. How many people work at the offices of the company?

___ 1 – 15   ___

___ 31 – 45   ___ 46 – 60

Culture Waste - People

19. What is the procedure to which candidates are subjected to the selection of staff?

___ Interview   ___ Test of knowledge

___ Psychological Test   ___ Other

20. Do you consider that the recruitment procedure is the best?

___ Yes   ___ No   ___ Maybe

Figure 4.3. Questionnaire designed for the office employees.

Interview with the manufacture workers

In the interview with manufacturing employees, the same topics covered in the office employees were used to develop the interview instrument:
- Culture
- Process
- Technology
- Environmental

Design the questionnaire

The questions were prepared based on an analysis of the potential waste of the company. Here is a list of different topics and possible waste in manufacturing (Glasow, 2005; Shah & Ward, 2007):

○ Culture
  ▪ People
  ▪ Processing
  ▪ Defect
  ▪ Waiting
  ▪ Environmental
○ Process
  ▪ People
  ▪ Overproduction
  ▪ Processing
  ▪ Waiting
  ▪ Inventory
  ▪ Motion
  ▪ Transportation
  ▪ Environmental
○ Technology
  ▪ People
  ▪ Processing
  ▪ Waiting
  ▪ Inventory
  ▪ Environmental
○ Environmental
  ▪ People
  ▪ Processing
  ▪ Defect
  ▪ Waiting
  ▪ Overproduction

- WIP Inventory
- Transportation

Questionnaire

PRODUCTION AREA

1. What is your job title?
_____

2. What are your responsibilities and duties in this company?
_____

3. How long have you worked for this company?
_____

4. How long have you held your current position?
_____

5. Are all directions given by the production manager supervisor to t[ ] understandable?

   ___ Completely clear   ___ Moderated clear

   ___ Low clear   ___ Not clear

   People -Waste

6. Do they communicate in time any changes in production process?

   ___ Always   ___ Usually

   ___ Sometimes   ___ Never

7. Are the orders, always informed personally or use some other means?

   ___ Personally   ___ Other means

8. How many people work in the shop of the company?

   ___ 1 – 15   ___ 16 – 30

   ___ 31 – 45   ___ 46 – 60

   General Information

9. How many machines are used to produce garments for your company?

   ___ One – five   ___ Six – ten

   ___ Eleven – fifteen   ___ Fifteen and more

   People waste - Trainning

10. Are the people employed in your company, properly trained for the job they do and their capabilities are fully exploited and used?

    ___ Completely prepared   ___ Moderately prepared

___ Low prepared   Process -Waiting   ...prepared
                                 Time

11. If something unexpect[___]...uction process, these are reported
    immediately?

    ___ Always   ___ Usually

    ___ Sometimes   ___ Never

12. What do you think it is wrong with the office process?

    _____

13. What is the workflow between the stages of the production process?

    ___ Manual   ___ Automated   ___ Mixed

14. How is the division of labor among shop employees in production processes?

    ___ Number of units   ___ Activities

15. How many orders are received per month?

    ___ 1 – 25   ___ 26 – 50

    ___ 51 – 75   ___ 76 or more

16. Is there a production process or unme[___] Process- IWaiting
                                              between processes
    ___ Yes   ___ Not sure

17. Is there a waiting time between process steps? Why?

    ___ Yes   ___ No

    Why? _____ Units/month   _____
                                Produced
18. How many units are produced month[___]

    ___ 1 -300   ___ 301 - 600

    ___ 601 -900   ___ 901 or more

19. How often is an order incomplete?

    ___ Always   ___ Usually

    ___ Sometimes   ___ Never

Figure 4.4. Questionnaire designed for the manufacturing employees.

Some of the questions were designed to be about information, another for information about office and manufacturing processes, and the others related to the final owner´s expectations in Throughput, cycle time, work in process, and quality.   Appendix B shows a table about the questionnaire used in the pilot case study.

Results

Based on the information obtained in the interview with the manufacturing employees, a problem identification was made according to the questions and observations conducted in the company, as detailed below:

	PROBLEMS IDENTIFY	Questionnaire and Observation
CULTURA	Renewing the staff constantly	Communication, Trainning
	No exploits the ability of the employee.	Order not written, Trainning, Production Plan
	Lack of selective hiring process.	Communication, Trainning not effective
	Lack of knowledge of the company by managers.	Orders not written, Quality and Communication Issues
	Employees do not share the same goals of the manager.	Do not have a quality control manual implemented
	Lack of Business Design	Processes and Documentation, Communication issues
PROCESOS	Lack of supervision in the process.	Quality Problems in Sewing and Cutting, do not know order processes
	Lack of transport for the distribution	WIP in different Areas of the company, The transportation of the raw material is not good
	Lack a specific process for the raw material.	Raw material is not inspected
	Unmet demand.	Unmet demand only with customer authorization (time)
WORK IN PROGRESS - LOGISTICS (TECHNOLOGY)	Cost of Maintenance of machinery.	Not preventive maintenance
	Waiting time between processes.	Delay for raw material from cutting process
	Lack of space for raw material.	Wip in every part of the company
	Lack of space for machinery.	Layout problems
	Constant maintenance of machine failures.	Not preventive maintenance
	Process for orders are not specify	Do not know the order processes
	There is no ISO Quality Certificate	Do not know processes and other documentation and quality issues
	Not workflow and production plan fails sometimes	Not documentation for workflow and production plan
ENVIRONMENT	They have not a recycling process.	Do not have any recycling program active
	It receives advice on matters of energy efficiency.	Nobody knows about the auditing process in Energy

Table 4.2. Company´s problems identified in manufacturing

4.1.3 IDEF0 modeling

IDEF0 modeling is widely used for developing processes, and Business Process Reengineering in different kind of companies. To make an IDEF0 diagram the following steps must be followed(Information & 183, 1993):

1. **Define Personnel roles:** In this step, author, expert, reader, and commenter are selected.
2. **Select Proper Modeling Parameters:** To develop a correct model, the purpose, viewpoint, and type of breakdown is made.
3. **Authoring an IDEF0 modeling:** In this step, diagrams, texts, layouts of the main and secondary paths are designed. The final diagram is validated using the "author reader cycle"(David A. Marca, 2006).
4. **Modelling peer review with the company:** In this final step, the Reader/Author cycle is made conducting walkthrough sessions with the company. Documentation is selected for each process, and process taps are designed.
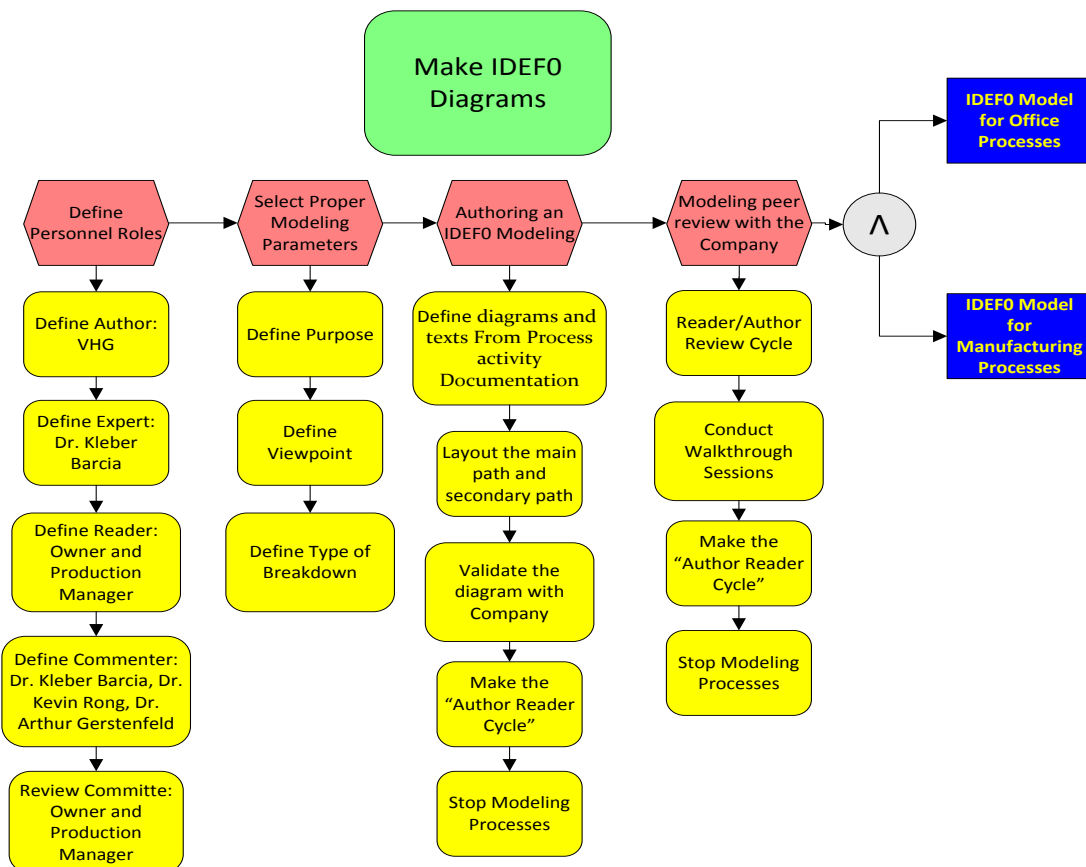
Figure 4.5. Steps to follow to develop an IDEF0 diagram for office, and Manufacturing.

Outputs: IDEF0 for The Company: Purpose and viewpoint (1)

In the next picture, IDEF0 diagram of a Textile Company is presented, which contains information on the purpose, inputs, outputs, mechanisms and controls on the manufacturing process around viewpoint of Author.

We can see that the textile company has:

Inputs:
o Customer requirements
o Financial Resources

Outputs:
o Finished product

Mechanisms:
o Human Resources
o Machinery
o Raw Material

Controls:
o Product features
o Budget
o Customer Demands

	Author:	Date: 11/09/2013	WORKING	READER	DATE	CONTEXT:
			DRAFT			
Used At:	Project: VICTOR HUGO GONZALEZ	Rev: 11/09/2013	RECOMMENDED	OWNER	16/08/2013	
	Notes: 1 2 3 4 5 6 7 8 9 10		PUBLICATION			

Purpose: Identify the processes in a Textile company, so a
guidebook for this kind of company would be developed.

Viewpoint: Author: VICTOR HUGO GONZALEZ

Budget   Customers Demands

Product Features

Customer Requirements →   MANUFACTURE THE
Financial Resources →   GARMENT   → Product Delivery
                                           0
                                          A0

Human Resources   Machinery
        Raw Materials

Node: A-0	Title: MANUFACTURE THE GARMENT	Number:
		Page: 1

Figure 4.6. IDEF0 modeling of the company: Office and Manufacturing

IDEF0 Main Processes

In the next figure, an IDEF0 of the Main Process of the Textile Company indicating distribution the processes of Office, and Manufacturing is presented, which contains information on the main processes of the company is shown:

- Reception – Receive order
- Management – Manage order
- Provision – Supply Raw Materials
- Production – Make Garment
- Storage – Layup Garment

Author:	Date: 11/09/2013	WORKING	READER	DATE	CONTEXT:
		DRAFT			☐
Used At:	Project: VICTOR GONZALEZ Rev: 11/09/2013	RECOMMENDED	OWNER		
	Notes: 1 2 3 4 5 6 7 8 9 10	PUBLICATION	16/09/2013		A-0

Product Features
Budget
Customers Demands
Customer Requirements
Financial Resources

Receive Order 1
A1
Garment quoted

Manage Order 2
A2
Order

Budget to buy materials
Suppliers

Supply Raw Materials 3
A3
Payment Method

Materials ready for production

Make Garment 4
A4
Product Packaged

Raw Materials
Machinery

Layup Garment 5
A5
Inventory
Product Delivery

Human Resources

| Node: A0 | Title: MANUFACTURE THE GARMENT | Number: |
| | | Page: 2 |

Figure 4.7. A-0. Manufacturing the garment. Processes involved, reception, management, provision, production, and storage.

Description of Main Processes

The priority of the company is to satisfy customer demands, which sells identifies and develops the function of each of the employees of the company, the machinery that will be needed, the trainings will be provided and quality controls.

This operation starts a chain order entry at reception (A1) is performed by the Assistant Front to hand the order to proceed with data entry and analysis administration quote (A2), it will be delivered to supply (A3) the report of materials required and the budget for each order. Supply will be responsible for inventory analysis, issuing purchase orders to suppliers and receiving the raw material for the production (A4) of the rules, which involve human resources and machinery for cutting, embroidery, printing, stitching and finishing, which will be supervised by the production and quality manager. Having completed the Jeans duly inspected the product moves Storage (A5) where they will be ready for delivery to customer garments.

Outputs: IDEF0 Office Processes

In the next picture, there will be presented on IDEF0 Office Process of the Textile Company indicating distribution the processes of Office, which contains information on the following:

oCustomer Service – Serve customer.
oProduct Design – Design product.
oOrder Quotation – Budget order.
oBilling – Bill order.
oOrder Report – Make order.

Used At:	Author:	Date: 11/09/2013	WORKING	READER	DATE	CONTEXT:
	Project: VICTOR HUGO GONZALEZ	Rev: 11/09/2013	DRAFT			
			RECOMMENDED	OWNER		
	Notes: 1 2 3 4 5 6 7 8 9 10		PUBLICATION	16/09/2013		A0

| Node: A1 | Title: Reception - RECEIVE ORDER | Number: Page: 4 |
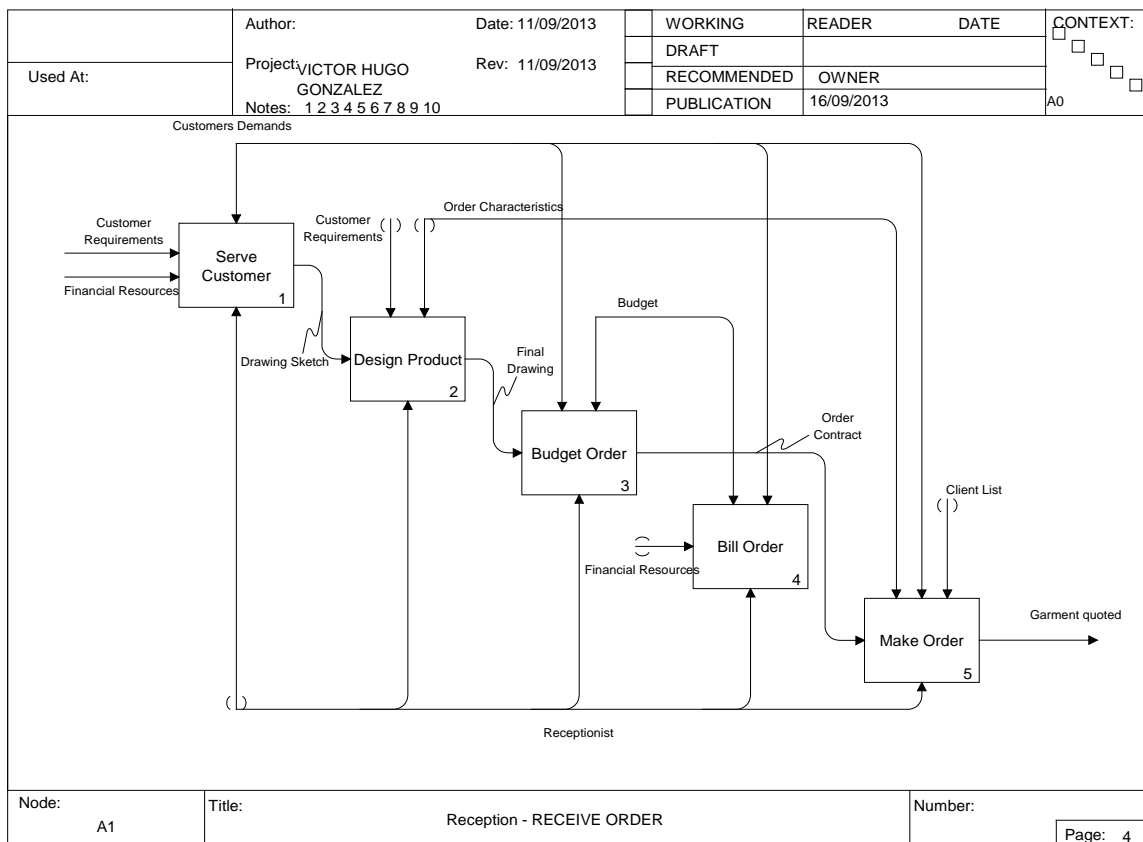
Figure 4.8. A1. Reception. Processes involved: customer service, product design, order quotation, billing, and order report.

Office Process Description
The operation in reception before sending to Management starts with Customer Service (A11) with the auxiliary reception, which is obtained from customer details, identifying needs and design specifications (A12) they want to purchase. Once the design is done, dimensions and size of the product, we proceed to order quotation (A13) products and, once

70

agreed, the client will provide the data and billing (A14), and the report is made (A15) to be sent to administration.

IDEF0 Production Processes

In the next picture the IDEF0 Process of the Textile Company will be presented, indicating distribution of the production processes, which contains information on these:

- Make the garment
- Control Quality
- Pack the Product
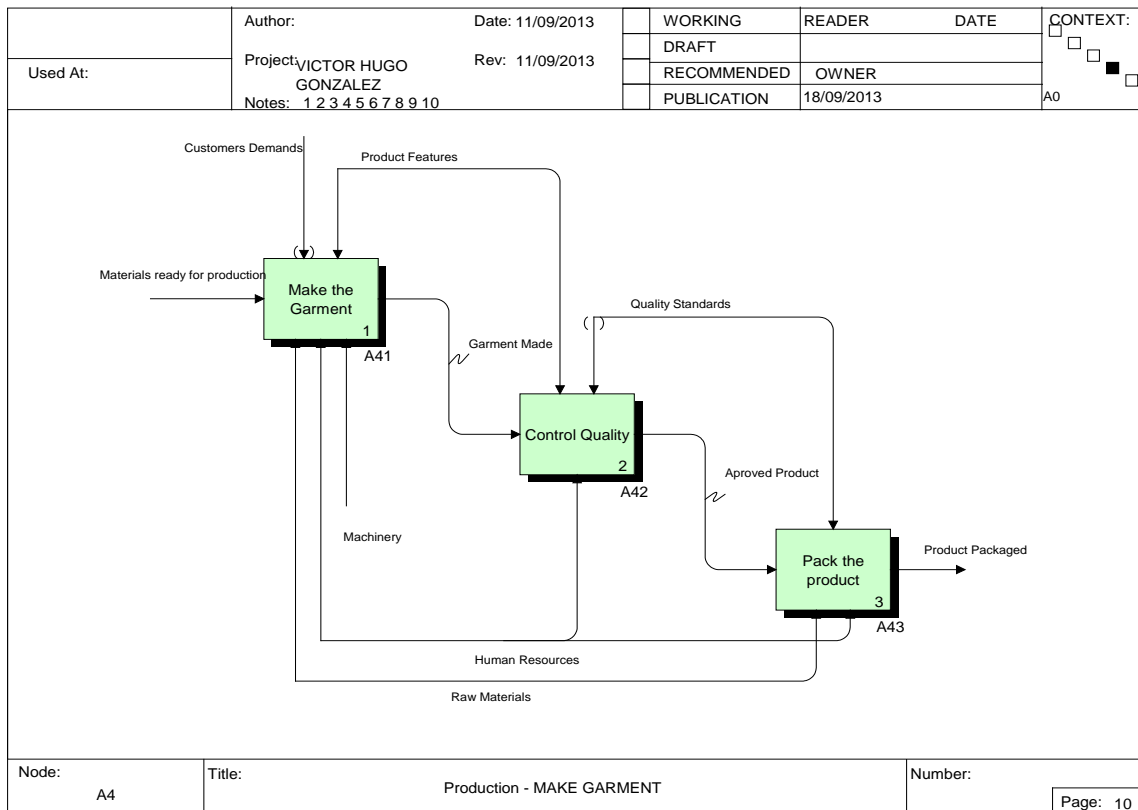
Figure 4.9. A4. Production. Make the Garment, Control Quality, and pack the product.

This is done starting from the preparation, or making the garment (A41) with design ideas proposed by the customer; once the garment is made (Figure 4.9), a quality control process is done (A42) supervised by the Head of Production and Quality Control, inspecting every garment to meet quality standards and customer requirements. Once accepted, the product moves to the packaging area (A43) where each product is packed according to customer specifications.

	Author:	Date: 17/09/2013		WORKING	READER	DATE	CONTEXT:
Used At:	Project: VICTOR HUGO GONZALEZ	Rev: 17/09/2013		DRAFT			
				RECOMMENDED			
	Notes: 1 2 3 4 5 6 7 8 9 10			PUBLICATION			A4

Product Features

Materials ready for production

Cut garment
1
A411

Mold Patterns

Embroidery garment
2
A412

Embroidered Pieces

Swage garment
3
A413

Sew Garment
4
A414

Stamped Parts

Uniforms Sewn

Finish garment
5
A415

Garment Made

Machinery

Raw Materials

Human Resources

Node: A41	Title: Make the Garment	Number: Page: 12

Figure 4.10. A411. Make the garment. Processes involved: cut the garment, embroider garment, swage garment, sew garment, and finish garment.

Specific details of the IDEF0 developed in different textile companies are in the Appendix B, in which all the processes are explained in detail.

4.1.4 Simulation of proposed solution

In the following flow, simulation represents the application of the Lean techniques.
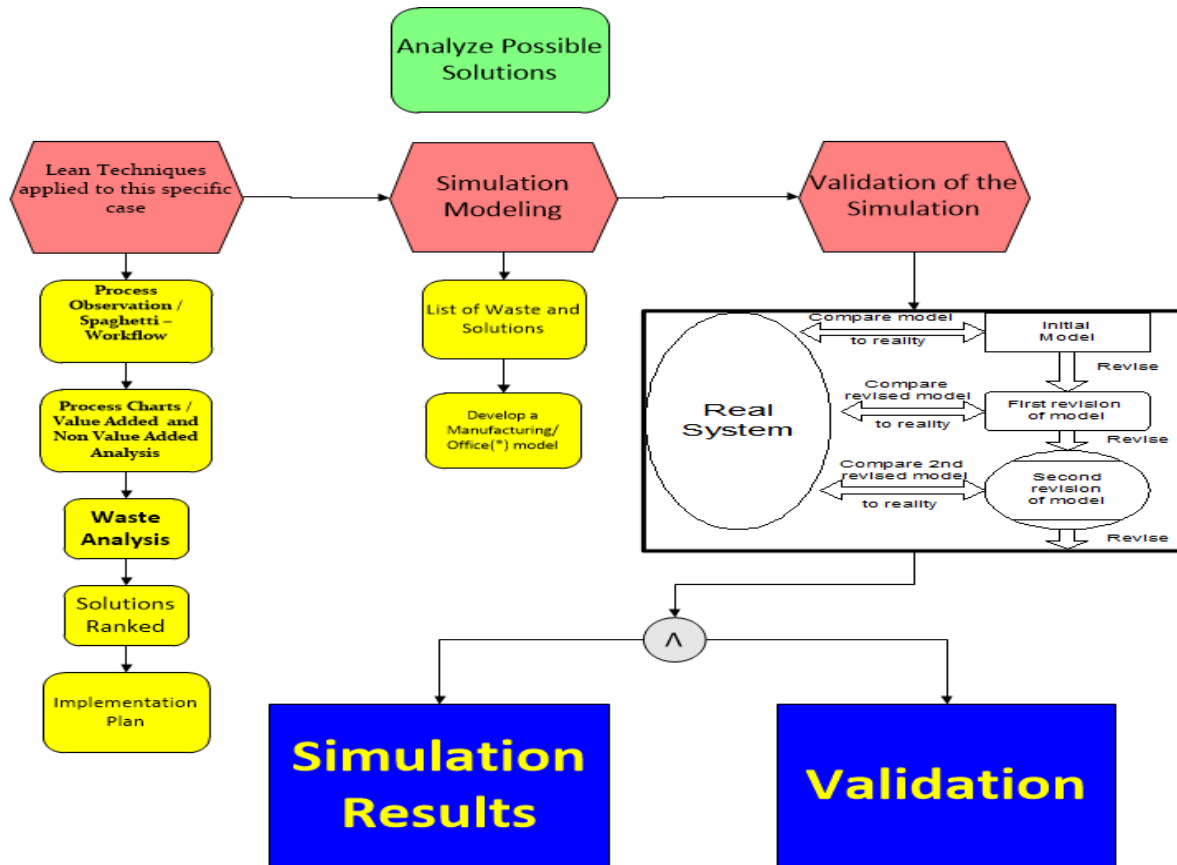
Figure 4.11. Analyze Possible Solutions; Steps in the methodology to validate the results.

4.2 Waste identification for office processes

According to interviews with office employees, the following wastes are identified in the process according to the topics set out above:

- Culture Problems
- o Communication
- o Training
- o Supervision in documents
- o Not Standards
- o Not Quality Standards

- Process Problems
  - Do not know the processes
  - No Order
  - No clear procedures
  - Documents waiting too long
  - No Standards
  - No Quality Standards
- Technology Problems
  - Focused in efficiency and cost
  - No quality orientation
  - No templates for processes
  - Have computers but not expertise
  - No standards
  - Not quality standards
- Environmental Problems
  - No recycling
  - Auditing without notice
  - No Energy plan

It can also be identified waste in the office environment:

- Information is unable to flow.
- Excessive information is generated and maintained.
- Inaccurate information flows resulting in corrective action or verification.

Different type of waste can be identified for the information generated in the company. In this case, the information cannot flow because it has not been generated; unable to flow because it cannot be identified or shared. Excessive information would be generated and maintained or inaccurate information flows resulting in inappropriate downstream activities, corrective action or verification. (Hicks, 2007)

4.3 Office Model: Proposed solution

Change to make
Below are the possible changes that the company should make in the textile processes office:

Office
o   Activity/ Process Templates.
o   Templates using same format for contracting different office   documents.
o   5S to apply in the office environment.

4.4 Current state of the company

In the interview with the owner, s/he allowed knowing the current state of the textile company. The topics discussed to obtain information and perform the analysis are:

- Company Advantages
- The expectations of the end results
- Processes Office

These are detailed below.

4.4.1. Company Advantages

In the interview with the owner, a SWOT (Strengths, Weakness, Opportunities and Threats) analysis was done. In this workshop, the company´s owner indicated the company has the following advantages:

Financial Advantages:
- Access to capital when required
- Degree of utilization of its borrowing capacity
- Ability of the company to exit the market easily
- Profitability, return on investment
- Liquidity

Competitiveness Advantages:
- Stronghold with suppliers and availability of inputs.
- Customer focus.
- After sales programs.

Technological Capabilities:
- Technical skill in manufacturing.
- Flexibility in manufacturing.

Advantages in Human Resources:
- Expertise.

4.4.2. Office and Manufacturing Processes

An office process chart was designed by a focus group with the company, and the following is the description of the activities to make a sweater or a particular garment:

op. #	Sweater	Inspection	Operation	Transport	Delay	Decision	Storage	Time Minutes	Distance **	VA - NVA
1	Customer Meeting with Manager				D			75	N/A	NVA
2	Designing the Contract				D			75	N/A	VA
3	Preparing the Order				D			45	N/A	VA
4	Design, Cloth Detail Patterns				D			120	N/A	VA
5	Verify Inventory				D			120	N/A	VA
6	Gap to Complete the order				D			120	N/A	VA
7	Order to Supplies				D			120	N/A	VA
8	Receiving Order from Suppliers				D			1440	N/A	NVA
9	Sending the order to cut the Fabric				D			45	N/A	NVA

** Office is too small to consider Distances

Table 4.3. Process chart: Main Office process activities for a textile company.

In this chart, there is a problem with the activities 8 and 9, which are "receiving order from suppliers" and "sending the order to cut the fabric". These two activities are the main problems in the office.

Activities for the production process

Once the office process is done, the manufacturing of the garment begins, and the activities for the different operations are designed with the owner and production manager, these are the following; cutting, and sewing processes.

The cutting process is done following the steps shown in the Table 4.4,

Steps	Activities for cutting lot of 1500 Shirts	Operations Inspection	Operation	Transport	Delay	Decision	Storage	Time (sec)	Distance (m)	VA - NVA
1	Customer Requirements Contract	☐	○	⇨	D	◇	△	3600	N/A	•
2	Design of patterns	☐	○	⇨	D	◇	△	7200	N/A	
3	Patterns according to customer requirements	☐	○	⇨	D	◇	△	200	N/A	VA
4	Cut the pattern in paper - one side	☐	○	⇨	D	◇	△	250	N/A	VA
5	Cut the pattern in paper - other side	☐	○	⇨	D	◇	△	250	N/A	VA
6	Cutting Sleeves Patterns	☐	○	⇨	D	◇	△	200	N/A	VA
7	Shrirt Collar cut	☐	○	⇨	D	◇	△	200	N/A	VA
8	Storage patterns	☐	○	⇨	D	◇	△	100	N/A	NVA
9	Move patterns for work in lots	☐	○	⇨	D	◇	△	600	5	NVA
10	Move production order to cutting zone	☐	○	⇨	D	◇	△	100	5	NVA
11	Arrival of patterns for work in lots	☐	○	⇨	D	◇	△	60	N/A	NVA
12	Verify order	☐	○	⇨	D	◇	△	90	N/A	NVA
13	Move patterns to cutting zone	☐	○	⇨	D	◇	△	50	5	NVA
14	Transport Fabric	☐	○	⇨	D	◇	△	600	20	NVA
15	Open fabric	☐	○	⇨	D	◇	△	500	10	NVA
16	Measure fabric	☐	○	⇨	D	◇	△	120	10	VA
17	Grouping for cutting fabric in lots of 100	☐	○	⇨	D	◇	△	100	N/A	VA
18	Patter scratch in fabric one side	☐	○	⇨	D	◇	△	60	N/A	VA
19	Cut fabric with Patter in lots of 100 units	☐	○	⇨	D	◇	△	120	N/A	VA

Table 4.4. Process chart: Cutting process activities for a textile company.

Following the Process chart, identifying Non-Value Added and Value Added activities, a lot of Work in Process is done (WIP). All the material cut is stored besides the cutting area. The following pictures were taken inside the company. As seen, there is a lot of WIP in the company.

Figure 4.12. Pictures from the Cutting process activities for a textile company.

The Sewing process is done following the steps of the Table 4.5,

op. #	Sweater	Inspection	Operation	Transport	Delay	Decision	Storage	Time	Distance	VA - NVA
1	WIP pockets/cuffs	□	O	⇨	D	◇	△	60		NVA
2	WIP Shoulders/Sleeves	□	O	⇨	D	◇	△	75		VA
3	WIP Necks	□	O	⇨	D	◇	△	10		VA
4	Cover with fabric	□	O	⇨	D	◇	△	20		VA
5	Join shoulders sides	□	O	⇨	D	◇	△	10		VA
6	Tipping the neck	□	O	⇨	D	◇	△	10		VA
7	Attach Ropes	□	O	⇨	D	◇	△	30		VA
8	WIP ropes	□	O	⇨	D	◇	△	20		NVA
9	WIP Shoulders/Sleeves	□	O	⇨	D	◇	△	20		NVA
10	WIP Necks	□	O	⇨	D	◇	△	20		NVA
11	Transport WIP Pockets/cuffs	□	O	⇨	D	◇	△	7		NVA
12	Transport wip shoulders/sides	□	O	⇨	D	◇	△	7		NVA
13	Transport WIP Necks	□	O	⇨	D	◇	△	10		NVA
14	Assembly	□	O	⇨	D	◇	△	100		VA
15	Transport to Inventory	□	O	⇨	D	◇	△	100		NVA

Table 4.5. Process chart: Sewing process activities for a textile company.

All the material generated in this process is stored as WIP in the production plant as show in the Figure 4.13.

Figure 4.13. Picture from the production process showing WIP from the different activities for a textile company and the sewing process.

Following the sewing process, a quality and packing process is observed. After these processes, an order is complete.

Making a primary observation of the company, it shows how the company works. In this particular textile company, a spaghetti diagram gives the idea of the disorder of its processes. The company urgently needs a reengineering and documentation for its processes. The following figure shows how the operations are done.
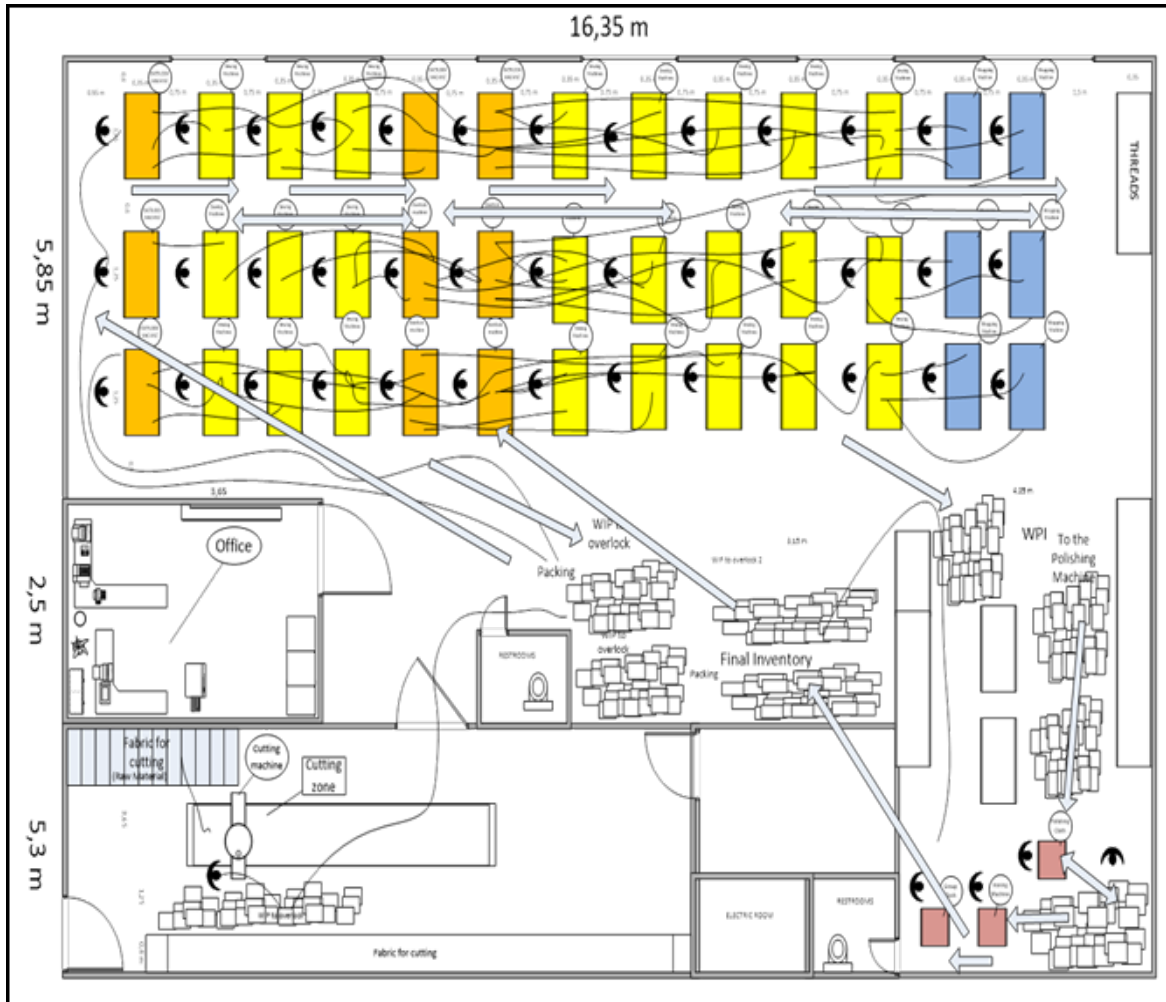
Figure 4.14. Layout of the production and office processes showing the different activities for a textile company.

4.5 Waste Analysis

From the interviews done for the owner, managers, and employees, a waste analysis was conducted to search for the different kinds of waste found in the pilot case (Textile Company). The waste analysis was divided in two parts: office processes and manufacturing processes.

4.5.1 Waste analysis results and solutions

Office Processes

The analysis of the information obtained from the interview with the office employee was classified following the four main expectations from the owner which are throughput, cycle time, work in progress and quality. Each one with a measure from the office and manufacturing processes.

Waste in Information is classified by Hicks as follows (2007).

○ Information that cannot flow because it has not been generated. The process is broken.
○ Information is unable to flow. It cannot be identified.
○ Excessive information is generated and maintained excessive information flows.
○ Inaccurate information flows demands corrective action or verification.

Based on this study, office waste was classified. Among several studies in manufacturing and service systems, the lean thinking process must be applied to eliminate waste, and enhance productivity.

The Lean Thinking philosophy, the value, value stream, flow and perfection is classified following three main aspects (Womack, 1996)

To identify waste in the office environment, questions from the questionnaire were designed considering two main aspects:

1. Type of waste: Culture, process, technology, and environment (Martin, 1995).
2. Main expectations in Throughput, cycle time, work in progress, and quality (defects)(Barcia, 2003).

Detailed results from the questions asked to the owner, office, and manufacturing employees are presented in the Appendix B. Measures were done in throughput, cycle time, work in progress, and quality. A detailed IDEF0 model of the company processes was analyzed, and a description of some waste of the company was identified. Main waste problems in the office processes are caused by overproduction, defects, processing, waiting, people, motion, transportation, and environment. Waste found in the office is shown in Table

4.6.   With this waste, the main causes of waste in this company was identified based on a scoring model (Table 4.7).

Areas of Waste

According to Melton, 2005 (Rawabdeh, 2005), waste was divided in 3 dimensions: Men, machines, and materials.   Overproduction and machines are caused by men and machines, and the defects would be caused by machines and materials.
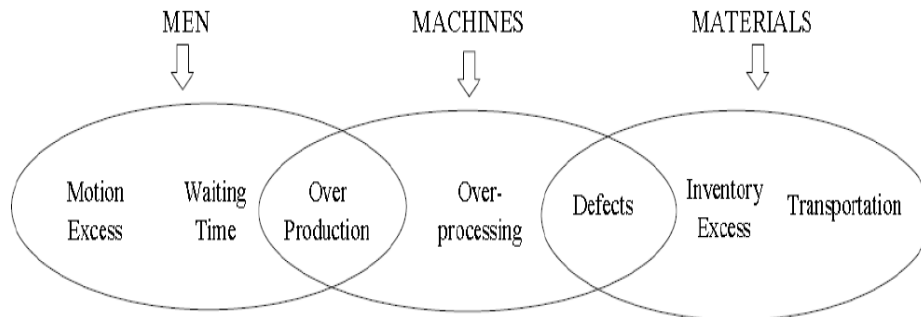
Figure 4.15. Areas of waste found in manufacturing. Taken from (Ramunė Čiarnienė, 2012).

These areas were considered when naming some of the waste found in the company. Some of the causes found are the following:

A.   Poor Layout
B.   Poor work methods
C.   Lack of adherence to process
D.   Incorrect performance measures
E.   Poor planning/forecasting
F.   Poor Supplier quality
G.   Long Setup time
H.   Lack of organization
I.   Lack of preventive Maintenance
J.   Lack of training

With the description in office environments (Kleber Barcia, 2002), the areas of waste in manufacturing identified (Ramunė Čiarnienė, 2012), and the specified causes for waste previously defined, a scoring model was developed to classify the main causes of company´s waste. This model began with the classification of the different kind of waste found in the

company, then taken the classification of waste of information given by Hicks (2007) and the lean thinking philosophy.

Final	
CULTURE PROBLEMS	**PROCESS PROBLEMS**
Comunication	Do not know the processes
Training	Nor order
Supervision in documents	Not clear procedures
Not Standards	Documents waiting too long
Not Quality Standards	No Standards
	Not Quality Standards
TECHNOLOGY PROBLEMS	**ENVIRONMENTAL PROBLEMS**
Focused in Efficiency and cost	Not recycling
Not Quality oriented	Auditing without notice
No templates for processes	Not Energy plan
Have computers but not expertise	
No standards	
Not Quality Standards	

Table 4.6. Waste found in office processes.

#	DESCRIPTION OF WASTE IN OFFICE ENVIRONMENTS	WASTE IN INFORMATION				WASTE IN MANUFACTURING									
		1	2	3	4	A	B	C	D	E	F	G	H	I	J
1.	Long process set-up	1													
2.	Unbalanced workload		1												
3.	Early preparation of reports			1											
4.	Existence of irrelevant data			1											
5.	Files piled up between work desks		1												
6.	Documents waiting to be matched or signed		1	1											
7.	Unfiled papers			1	1										
10.	Lack of focus on company's objective														1
11.	Weak organizational structure												1		
12.	Ineffective supervision												1		1
13.	Rushed processes						1	1	1						
14.	Confusing procedures		1				1								
15.	lack of checklists		1	1									1		1
16.	Redundant approval / Inspection		1	1			1								
17.	Non-standardized business process	1	1				1								
18.	Re-entering data	1	1				1								
19.	Printing & mailing, faxing, overnight mailing, and emailing the same memo			1	1		1	1							
22.	Printing document twice just-in-case			1			1		1						
23.	Repetition of same information in different forms			1			1		1						
27.	Making a draft before preparing formal document			1	1		1		1	1			1		1
29.	Poor document flow scheduling				1	1	1								
32.	Too many defects	1			1		1	1	1				1		1
33.	Walking back and forth to correct mistakes	1			1	1									1
39.	Poor design of forms and equipment	1							1	1			1		
42.	Lack of communication/information		1		1		1		1						1
43.	Improperly trained/unskilled employees												1		1
44.	Performing monotonous work			1		1	1			1					
47.	Not providing opportunity for growth								1				1		

DESCRIPTION OF WASTE IN OFFICE ENVIRONMENTS	IDENTIFY IN THE COMPANY	WASTE IN INFORMATION					LEAN THINKING								
		WASTE IN INFORMATION					WASTE IN MANUFACTURING								
		1	2	3	4		A	B	C	D	E	F	G	H	I	J
		6	8	11	8		3	13	3	8	3	0	0	8	0	8

SCORING THE WASTE FOUND IN THE COMPANY

Waste in information

2. Information is unable to flow

3. Excessive information is generated and maintained

4. Inaccurate information flows resulting in corrective action or verification.

Waste in following principles of Manufacturing

B. Poor work methods

D. Incorrect performance measures

H. Lack of organization

J. Lack of training

Tables 4.7. Scoring the waste in office environment found in the company.

Final results from the company show that there is waste in information that is unable to flow, excessive information is generated, and inaccurate information is flowing in the company. All this waste of information is because of poor work methods, incorrect performance measures, lack of organizations, and lack of training. An implementation plan for the office is done for these purposes.

Manufacturing Processes

Following the same methodology used to analyze the waste in office environments and the four main expectations from the owner, which are throughput, cycle time, work in progress and quality, it was designed a scoring model to analyze, and prioritize. Waste was classified in culture, processes, technology, and environmental.

From the questionnaire, a classification of waste was found as shown in Table 4.8. In this table, the main causes of the waste are in culture and technology. In the Figure 4.16, a graphic of the main causes of waste is presented.

	PROBLEMS IDENTIFY	SOLUTIONS	Lean Manufacturing Techniques
CULTURA	Renewing the staff constantly	Reduce the constant firing, to staff training stable	3, 9, 11
	No exploits the ability of the employee.	Encourage staff and operate as necessary and what is proposed skilled.	2, 3, 7,9,13, 14
	Lack of selective hiring process.	Create a selection process to avoid the constant resignation or dismissal.	2
	Lack of knowledge of the company by managers.		
	Employees do not share the same goals of the manager.		
	Lack of Business Design		
PROCESOS	Lack of supervision in the process.	Train employees to do the function of supervisor, for a better process.	1, 2, 3
	Lack of transport for the distribution		
	Lack a specific process for the raw material.		
	Unmet demand.		
WORK IN PROGRESS - LOGISTICS (TECHNOLOGY)	Cost of Maintenance of machinery.		
	Waiting time between processes.	Improve Machine Location and increased supervision of staff.	7, 9, 11, 13
	Lack of space for raw material.	Arrange the raw material inventory and conducting a respective also creating space for it.	9, 11, 12, 13, 14
	Lack of space for machinery.	Relocating machines for the process efficient and to avoid wasting space.	7. 12, 13
	Waste of space.	It will include the relocation of machinery and inventory organization.	8, 9, 11, 12, 14
	Constant maintenance of machine failures.		
	Distance from workshop and office.		
	There is no ISO Quality Certificate	Design a process that serves to meet the company for ISO quality certification.	12, 13, 14
AMBIENTAL	They have not a recycling process.	Create a recycling process of the company to prevent pollution.	9, 12, 14
	It receives advice on matters of energy efficiency.	Train staff on energy saving.	1,2,3

Table 4.8. Waste found in manufacturing processes and lean techniques to solve them.
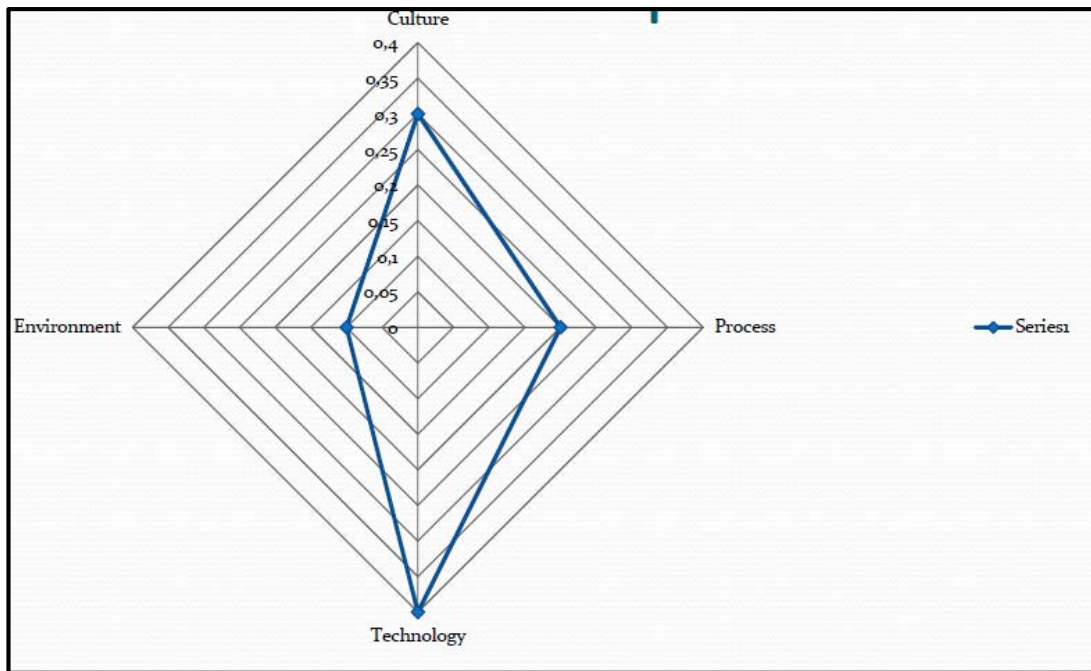
Figure 4.16. Main causes of waste.

Lean manufacturing techniques were used to assess the current situation of the company. Table 4.10 mentions these techniques.

LEAN TECHNIQUES	
1	5S
2	TEAM WORK
3	CROSS TRAINING
4	QUICK CHANGEOVER
5	TOTAL PRODUCTIVE MAINTENANCE
6	POINT OF USE STORAGE
7	CELLULAR LAYOUT
8	PULL SYSTEM
9	STANDARDIZED WORK INSTRUCTIONS
10	POKA- JOKE
11	Mixed/Level-Loaded Production
12	INVENTORY AND LEAD TIME REDUCTION
13	KANBAN IMPLEMENTATION
14	QUALITY ON SOURCE

Table 4.9. Lean Manufacturing Techniques generally used in SMS companies.

Ranking solutions

Having the problems of waste of the enterprise identified, a hierarchy model to select the most suitable lean techniques to be applied was designed.

It starts with the ranking of the techniques needed to solve the problems in the manufacturing environment with respect to cost, and then impact. Once given the weights of relationships between these two factors, a weight process for each variable assigning the cost one-weighting of 30% and 70% to impact. In Table 4.11, the final results of this weighting are given, leaving the 5S, quality at the source, and standardized work instructions techniques as the first to be implemented in the company in order to have an improvement in their processes and stable growth.

Hierachy Matrix for lean Mfe Solutions for a textile Company	IMPACT									
		1	3	7	9	11	12	13	14	Total
5S	1		5	5	10	5	5	5	0,2	35,2
Cross Training	3	0,2			0,1	1	1	1	5	8,3
Cellular Layout	7	0,2			0,2	1	0,2	5	0,1	6,5
Standardized work Instructions	9	0,1	10	5		10	0,2	1	1	27,3
Mixed/Level - Loaded Production	11	0,2	1	1	0,1		5	0,1	0,2	7,6
Inventory and Lead time reduction	12	0,2	1	5	5	0,2		1	0,2	12,6
Kanban implementation	13	0,2	1	0,2	1	10	1		0,2	13,6
Quality on Source	14	5	0,2	10	1	5	5	5		31,2

Hierachy Matrix for lean Mfe Solutions for a textile Company	COST									
		1	3	7	9	11	12	13	14	Total
5S	1		5	5	1	10	10	10	5	46
Cross Training	3	0,2		10	0,2	1	1	1	0,2	13,6
Cellular Layout	7	1	0,1		0,2	1	0,2	0,2	0,1	2,6
Standardized work Instructions	9	0,1	5	5		10	5	1	1	27,1
Mixed/Level - Loaded Production	11	0,1	1	1	0,1		1	1	0,2	4,4
Inventory and Lead time reduction	12	0,1	1	5	0,2	1		1	1	9,3
Kanban implementation	13	0,1	1	5	1	1	1		1	10,1
Quality on Source	14	0,2	5	10	1	5	1	1		23,2

	Cost (0.3)	Impact (0.7)	T. Weighted
Weight	**0,3**	**0,7**	**1**
5S	13,8	24,64	**38,44**
Quality on source	6,96	21,84	**28,8**
Standardized Work Instructions	8,13	19,11	**27,24**
Kanban Implementation	3,03	9,52	**12,55**

Table 4.10. Hierarchy model to select the most suitable lean techniques to be applied.

From this table, 5S, Quality on source and Standardized Work Instructions are the Lean techniques to be implemented in this company. These techniques will be implemented in the simulation model to get a future state of the company. In this future state, throughput, cycle time, WIP and quality will be measured.

4.5.2 Expected results

The expect results of office and manufacturing processes according to the owner:

METRICS	BEFORE IMPROVEMENT	EXPECTATIONS
Throughput	Quotations/Day	Increase % 50
Cycle Time	Hrs./Quotation	Reduce % 80
Work in Process	Quotation in 1 Workday	Reduce % 50
Quality	Quotations/Day are Rejected	Improve % 90

METRICS	BEFORE IMPROVEMENT	EXPECTATIONS
Throughput	Units/Day	Increase % 100
Cycle Time	Min./Unit	Reduce % 40
Work in Process	Units in 1 Workday	Reduce % 90
Quality	Unit/Day are Rejected	Improve % 95

Table 4.11. Final expectations of metrics in office and manufacturing for the textile enterprise.

To evaluate these metrics, a simulation software has been used, Witness®. Using this software will allow us to prove, from the actual manufacturing system that the changes needed will be effective in the company.

From the changes in these metrics, it is analyzed as follows:

Throughput: The unit of measure of this metric is Quotations/day. In the office, the customer service time is a critical factor to be considered. In manufacturing, the number of units produced by day is analyzed. Time and movements were taken in order to improve its processes.

Cycle time: The unit of measure of this metric is hr. /quotations (office) or min/unit (manufacturing). It takes the time needed to finish a quotation or unit in the office or Manufacturing.

Work in Process: This kind of metric is measured taken the number of units that are waiting to be processed.

Quality: The quality, following the owner´s perspective, will be the number of defects or units to be reprocessed.

Other records were developed with the processes. These are the following:

- Records of Business Processes for all the company, changing some of the actual records.
- Office Templates for contracts, orders, and common letters.
- Records of Manufacturing Processes for all the company changing some of the actual records.
- Manufacturing Templates.
- A way to enhance productivity.
- A way to improve processes.
- To initiate a quality certification process with the Government.

Following the applications of the 5S, Quality on source, and Standardized Work Instructions, some measures from the Initial conditions would improve to expect Future Conditions:

ONE PRODUCT			
Measures	Present	Expectative	After Improvements
Production	240 shirts/day	Increase 45%	350 shirts/Day
Cicle Time	36 seconds/shirt	Reduce 33%	24 seconds/Shirt
Total WIP	500 shirts/day	Reduce 80%	100 shirts/ Day
Quality	25 shirts/Day defected	Reduce 95%	3 shirts/Day defected

Table 4.12. Final expectations of metrics in office and manufacturing for the textile enterprise – future conditions.

To begin with the improvements needed a documentation of all processes were developed. Office and production processes were design based on meetings with the owner and production manager, following simple steps to generate the process activity documentation. The first step was the meeting with the office manager/owner of the company. In this step, processes, codes, times, validation kits, and validation from different office employees was done. As a result, each process designed has code, objective, activities to be performed, times, inputs, outputs, indicators, records, and associated documents. Some of these documents were described "in house" to be used in the company. A process activity is shown in Figure 4.17.

Process Activity			
Code:	A1	Version:	1
Date of Preparation:	August 2012	Date of Approval:	September 2012
Process	RECEPTION		
Objective:	Greet customers, identifying their needs details and specifications regarding your order.		
Worker in charge:	Recepcionist		
Activities	Customer service (5 minutes) Acquire uniform design (15 minutes) Quote Order (10 minutes) Turnover (5 minutes) Presentation of Report of orders (15 minutes)		
Inputs:	Features Order Customer information Amount requested uniforms Monetary resources		
Outputs:	quotation billing Report orders		
Indicators:	Customer Demands		
Records:	Customers Sheets Sheets deliveries		
Documents:	Order Notes invoices		

Figure 4.17. Process Activity of the reception process.

A methodology that involves both office and production processes was developed (Figure 4.18).

Process Activity

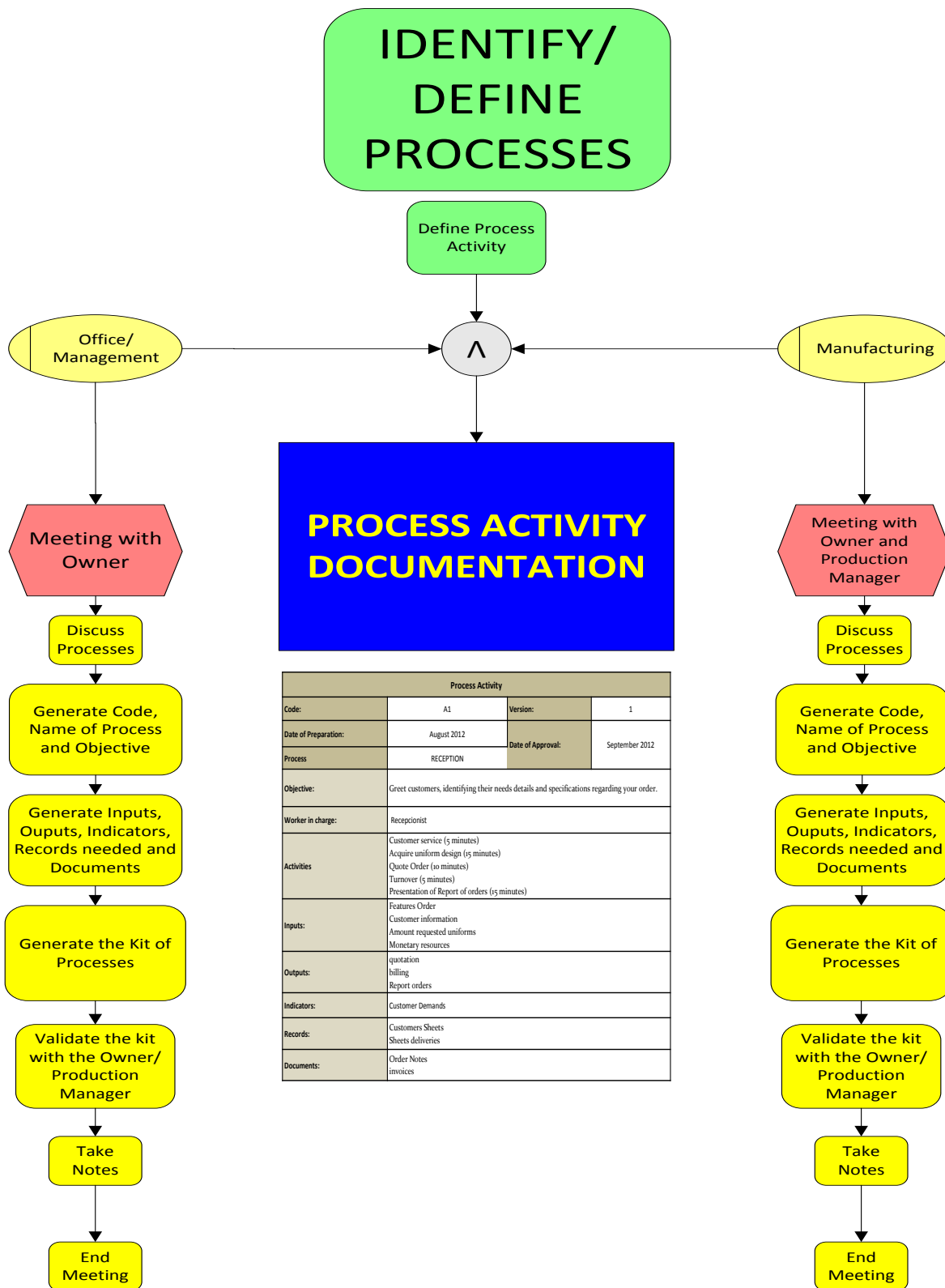| Code:	A1	Version:	1
Date of Preparation:	August 2012	**Date of Approval:**	September 2012
Process	RECEPTION		
Objective:	Greet customers, identifying their needs details and specifications regarding your order.		
Worker in charge:	Recepcionist		
Activities	Customer service (5 minutes) Acquire uniform design (15 minutes) Quote Order (10 minutes) Turnover (5 minutes) Presentation of Report of orders (15 minutes)		
Inputs:	Features Order Customer information Amount requested uniforms Monetary resources		
Outputs:	quotation billing Report orders		
Indicators:	Customer Demands		
Records:	Customers Sheets Sheets deliveries		
Documents:	Order Notes invoices		

Figure 4.18. Methodology applied to get a Process Activity chart for the reception process.

To prove that the changes were effective, a simulation model of this company was done.

4.6 Simulation model

In the current analysis, the company has bottlenecks for cutting raw material required in orders and packaging of the finished product. This is because the cycle time in these areas is too large. The General Manager performs many activities at once causing orders queued until they are processed.
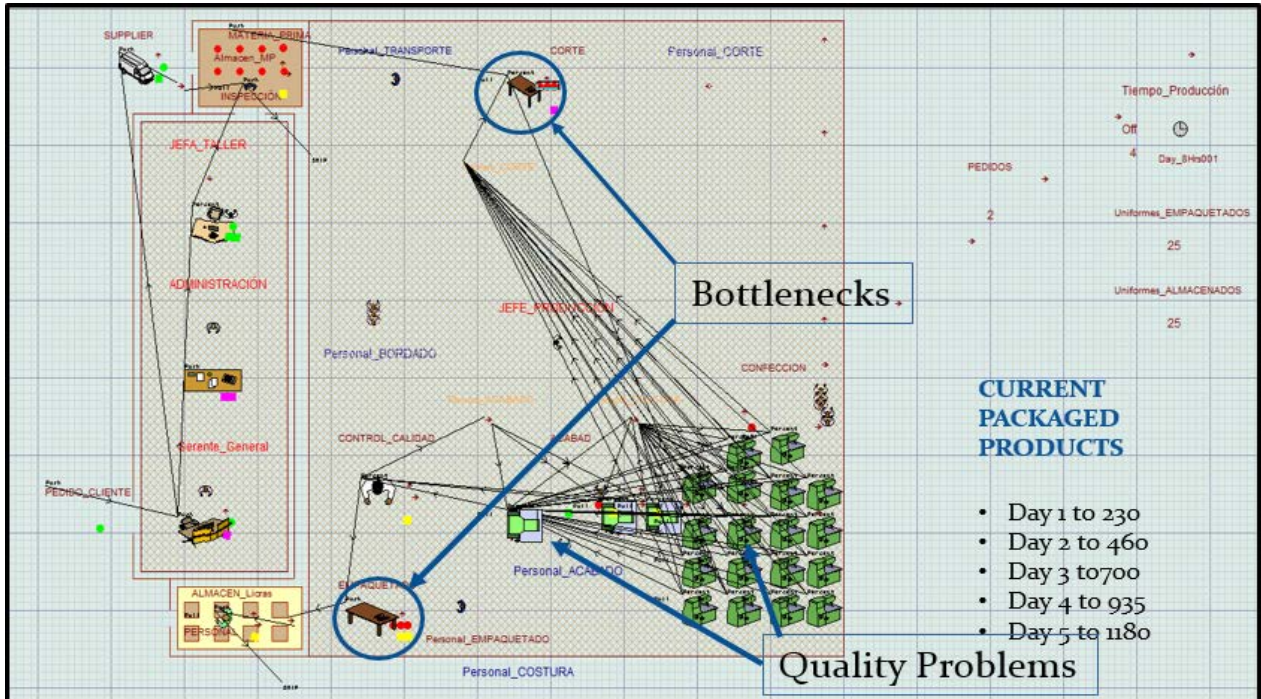
Before improvements

Figure 4.19. Simulation model of actual conditions.

To improve these bottlenecks resort to adding an additional machine that required cuts are made in less time.

Machines were also used to improve the packing area, adding a board to allow the items to be packed in the shortest time possible. For the General Manager, it meant having more time available to open new customer relationships.

NOTE: All changes are specifically detailed in the process charts, changes such as creating templates, Dropbox account, buying a new laptop, etc.
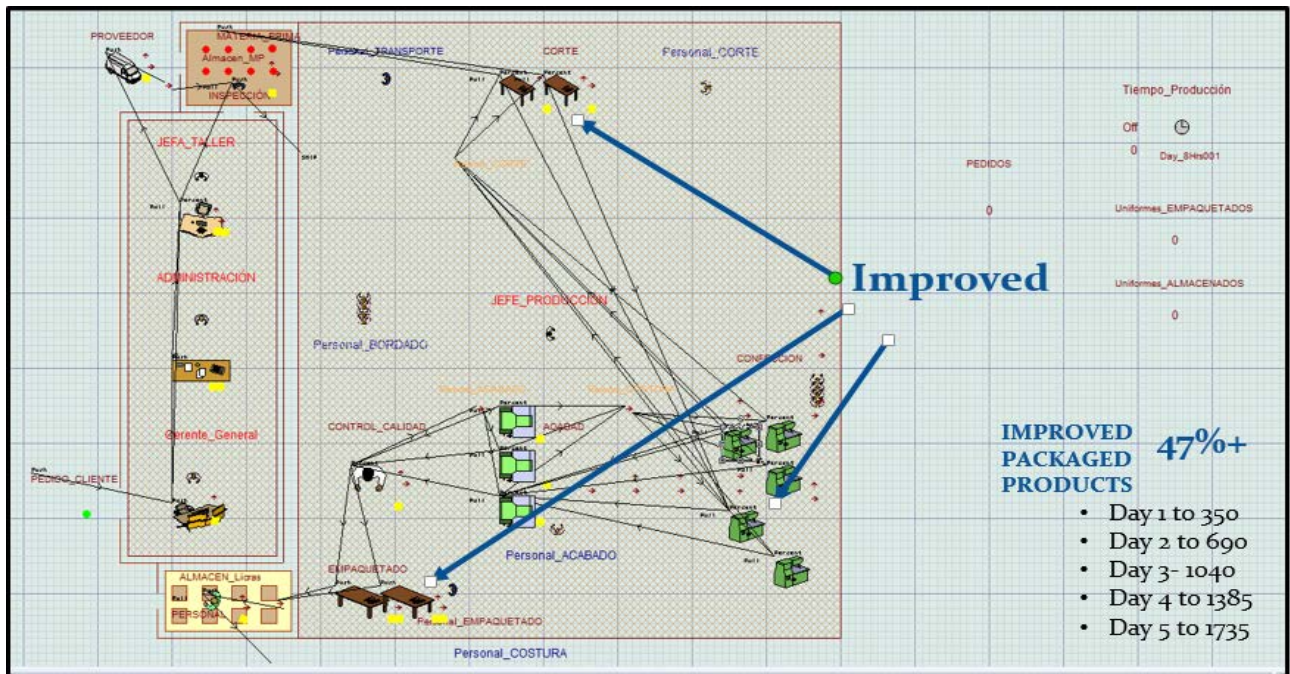
- **After Improvements**

Figure 4.20. Simulation model of future conditions.

Implementing 5S, standardized work, process activities documentation, and some Information systems in the company would enhance productivity, and the four parameters discussed previously, lead the company to lean transformation, improving cycle time, throughput, quality, and work in progress.

The following table shows the improvement in production that this system would have if they follow the instructions to eliminate waste.

PACKAGED PRODUTS CURRENT	IMPROVED PACKAGED PRODUCTS
Day 1 to 230 Day 2 to 460 Day 3 to700 Day 4 to 935 Day 5 to 1180	Day 1 to 350 Day 2 to 690 Day 3- 1040 Day 4 to 1385 Day 5 to 1735

Table 4.13. Improvements in production using Simulation Software.

From the Figure 4.21, it is seen that the company clearly needs a 5S implementation program. They have low order time and documentation, higher WIP, and lower quality (measured as pieces defected by day), some problems are shown in the pictures below, Figure 4.21.

Figure 4.21. Actual conditions. Problems in Standardized work documents, WIP, and quality.

4.7 Case study reports

Once the simulation is done, Lean techniques to be implemented indicates the increase in daily production, which generates a higher profit as detailed in the following table

PACKAGED PRODUTS CURRENT	IMPROVED PACKAGED PRODUCTS
Day 1 to 230	Day 1 to 350
Day 2 to 460	Day 2 to 690
Day 3 to700	Day 3- 1040
Day 4 to 935	Day 4 to 1385
Day 5 to 1180	Day 5 to 1735

In the current process was observed an average production of 230 units per day. In the improved process was observed an average production of 350 shirts per day.

One of the main problems was to demonstrate to the owner about the profit he/she would make if the changes are made. A spread-sheet simulation model was developed using @Risk ® a Palisade Decision tools. In the following figure, it is show the flow used to develop this model.
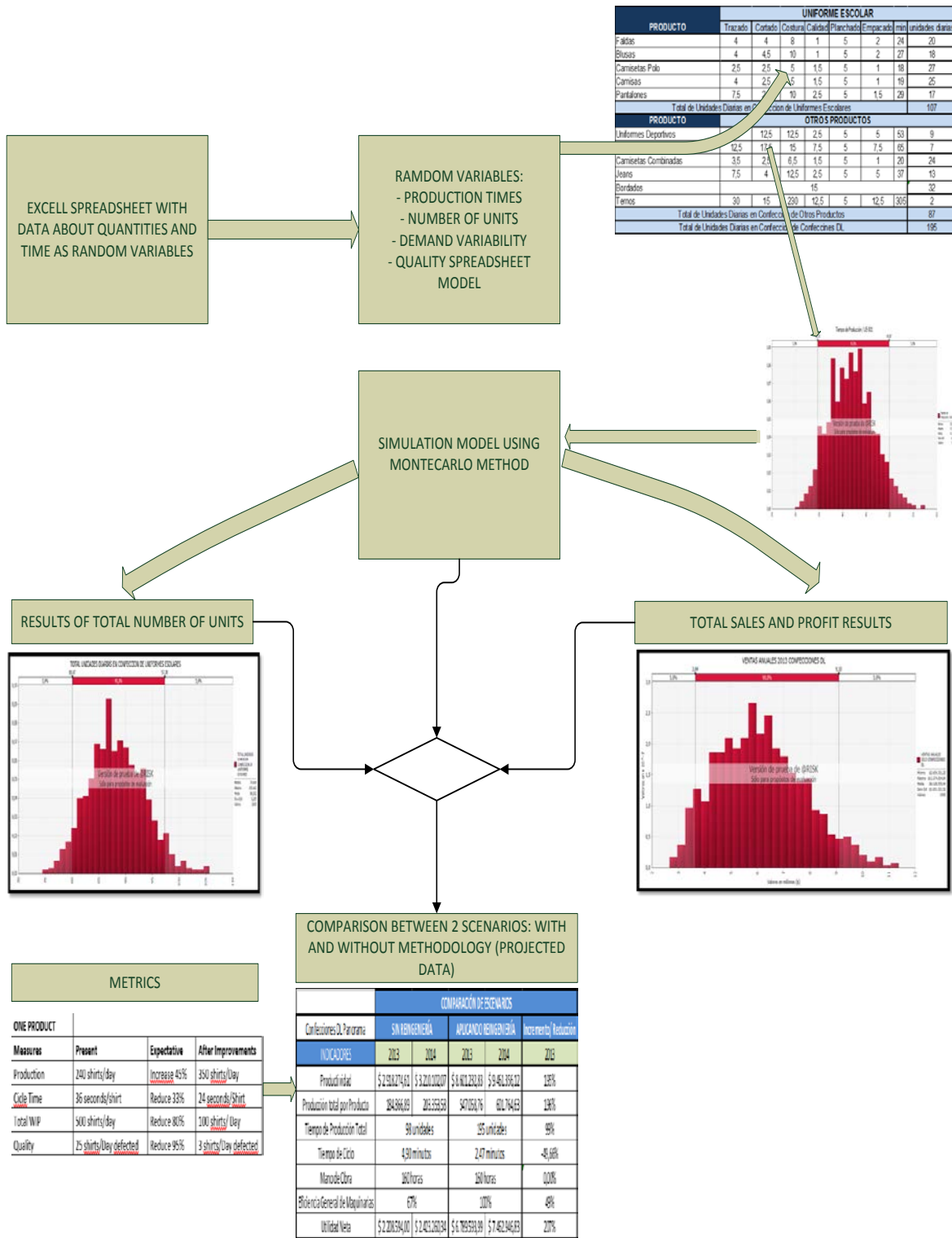
Figure 4.22. Spreadsheet simulation model using @Risk® to make a comparison between scenarios.

In this flow, it begins with the selection of the random distribution functions for different variables in the spreadsheet, such as production times, number of units, demand variability, etc. Once these variables are identified, different outputs from the model are selected and the results reflects a 95% interval of the value of the number of units and profit results.

Once proving the effectiveness of this methodology, a document was presented to the owner for his/her evaluation process.

Three different companies were analyzed using this methodology, and the results of the problems found were the following:

PROBLEMS TEXTILE COMPANIES (SMS COMPANIES)	COMPANY NF			COMPANY CDG	COMPANY Z
CULTURE - PROCESSES	Lack of supervision in the process.	No exploits the ability of the employee.		Waiting time between processes	Communications problems between office&Manufacturing
PROCESSES - TECHNOLOG	Lack of transport for the distribution	Lack a specific process for the raw material.		Low storage capacity, High WIP	No Documents for manufacturing (verbal instructions)
CULTURE - TECHNOLOGY	Lack of selective hiring process.	Renewing the staff constantly		Unbalanced workload	Low Trainning to the employees
SKILLS/TRAINNING	Lack of knowledge of the company by managers.	Employees do not share the same goals of the manager.	Constant maintenance of machine failures.	Long Work process set-up time	Do not know the processes of the company (O&M)
DOCUMENTATION	Lack of Business Design	Cost of Maintenance of machinery.		No documents for Office processes & manufacturing	Do not know how many machines work for production
QUALITY-PRODUCTIVITY	Waiting time between processes.	Lack of space for raw material.	Lack of space for machinery.	High amount of defects	Quality on source is not done
DOCUMENTATION	Process for orders are not specify	There is no ISO Quality Certificate	Unmet demand.	Processes Draft	No documentation templates for office
CULTURE-OFFICE	Not workflow and production plan fails sometimes	They have not a recycling process.	It receives advice on matters of energy efficiency.		No database of customers
OPERATIONS/PROCESSES	None			None	None
THROUGHPUT	240 shirts/day			16 uniforms/day	10 uniforms/day
CYCLE TIME	120 seconds/shirt			1800 seconds/uniforms	2880 seconds/uniform
WORK IN PROCESS	500 shirts/day			10 Uniforms/day	4 uniforms/day
COST	Medium			High	High
QUALITY	25 shirts/Day defected			5 Uniforms/day	2 uniforms/day

Table 4.14. Problems of three SME textile companies in office and manufacturing.

Results from different companies for the effectiveness of this methodology are shown in the following table:

ONE PRODUCT	COMPANY NF		
Measures	Present	Expectative	After Improvements
Production	240 shirts/day	Increase 45%	350 shirts/Day
Cicle Time	120 seconds/shirt	Reduce 80%	24 seconds/Shirt
Total WIP	500 shirts/day	Reduce 80%	100 shirts/ Day
Quality	25 shirts/Day defected	Reduce 95%	defected
ONE PRODUCT	COMPANY CDG		
Measures	Present	Expectative	After Improvements
Production	16 uniforms/day	Increase 63,5 %	26 uniforms/Day
Cicle Time	1800 seconds/uniforms	Reduce 37%	1107,7 seconds/uniforms
Total WIP	10 Uniforms/day	Reduce 50%	5 uniforms/ Day
Quality	5 uniform/Day defected	Reduce80%	1 uniforms/Day defected
ONE PRODUCT	COMPANY Z		
Measures	Present	Expectative	After Improvements
Production	10 uniforms/day	Increase 50%	15 uniforms/Day
Cicle Time	2880 seconds/uniform	Reduce 33%	1920 seconds/uniform
Total WIP	4 uniforms/day	Reduce 75%	1 uniforms/ Day
Quality	2 Uniforms/Day defected	Reduce 95%	0 uniforms/Day defected

Table 4.15. Table of simulation results for three different SMS textile companies.

All the results were positive in its expectations and were presented to the owners of the SMS companies.   More results can be found in Appendix C.

CHAPTER 5

CONCLUSIONS AND CONTRIBUTIONS

5.1 Conclusions

According to the main objectives of this research, the conclusions are the following:

1.   A methodology as an engineering approach to transform office and manufacturing environment was developed for a SMS of a particular sector (textile industry sector). This model shows how to transform an office and a manufacturing textile company from a current state to a desired future condition, proven the effectiveness of the methodology through simulation modeling (Witness® Modeling, and Spreadsheet modeling using @Risk®) The first model was developed under the criterion of lean principles to show a SMS company production optimization (Manufacturing), and the second one under the criterion of uncertainty in financial flows following all the recommendations given in the manufacturing simulation (Administrative, and services). The model has integrated cultural, process, and technology strategies to transform the enterprise

2.   A field engineer's guidebook for implementing this methodology was developed to guide the transformation of the company from a current state to a lean condition with the application of the developed methodology. This guidebook was presented in Ecuador in the "workshop of Business and Economics – 2013", in which the office and manufacturing environments were presented as a whole connected and interdependent system (Appendix A).

3.   This methodology is easy to implement demanding low investment, creating a documentation system to support waste elimination, reducing cycle time and enhancing productivity. Figure 5.1 shows the advantages of using the proposed methodology.
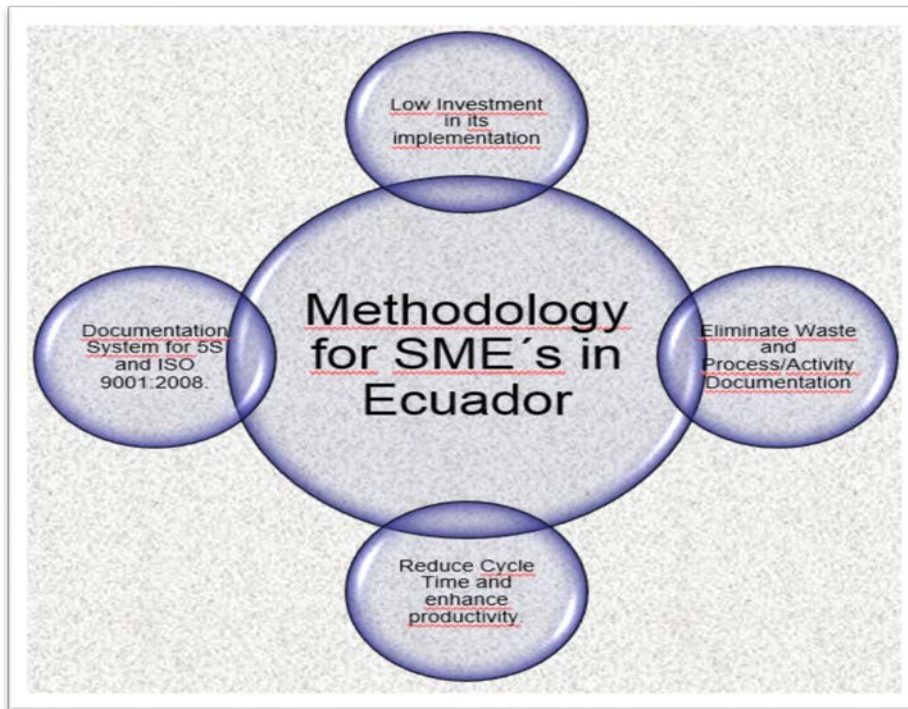
Figure 5.1. Advantages of using SME´s methodology.

5.2 Contributions

1.   A methodology is developed,

In its first step, it takes information directly from the customer, in this case, the company.   Problems or waste were identified from culture, process, technology and environment.   A Survey/Interview was developed in this research.   Its main goal was to identify waste in different Manufacturing & Office processes.   Limitations in these steps are as follows:

- Unbiased answers are difficult to get when the owner participates with the employees.

- This interview/questionnaire was developed for textile companies, family owner, a different kind of company must require experts to identify waste from office & manufacturing processes.

• This interview/questionnaire was only to identify waste from culture, process, technology, and environment. Steps for processes, times and movements, and other issues were identified with observation´s notes in Office & Manufacturing.

In the second step, general documentation was generated for office & manufacturing operations to improve company´s operations, work methods, and reduce defects enhancing quality control. For this purpose two IDEF0 diagrams were developed. The first one was to identify old processes, its relationship, and hierarchy. In the second IDEF0 diagram, new processes needed were designed. To support them, process/activity documents were diagramed as well as work methods to support them.

In the step 3, Simulation was used to verify the effectiveness of changes and optimize the model. Using Scenario Analysis, a simulation model showing improvements and documentation is presented in different areas. Achieved improvements are shown in the model for future decisions.

In the simulation model, a scenario analysis was applied, and the results after making some changes are shown in Table 4.15.

Based on the simulation results, it clearly reflects an increasing value in productivity, measured as production, cycle time, total WIP, and quality. On average, productivity has increased in 61.38% of its original value. The methodology proposed in this research has been shown in the textile sector in the workshop of economics and social science in Ecuador but much must be done to other industrial sector to prove effectiveness in reducing waste and increasing productivity in other companies of manufacturing in Ecuador. All these results are reflected in income which increased by 119%, when changes are applied. With small changes, the factory would double its income rate!!

This study has shown that applying lean manufacturing techniques to selected industries can reduce their dependence on outsourcing.   Production increased on average 52.84%. This could be due to the fact that in the nearly future enhancing the production rate of this kind of companies, they would become so competitive that the outsourcing can be significantly reduced and, in fact, reduced enough to change the balance of trade in Ecuador.

2.   The second contribution of this research is the development of the guidebook for consultants.   This implementation guidebook concentrating on office-manufacturing environment is the first developed in engineering literature for a developing country like Ecuador.

3.   The third contribution is the documentation process to initiate ISO9001:2008 developing a Quality manual "model" for this kind of companies shown in appendix B. A process approach was done and is shown in appendix B the quality manual.

4.   A documentation system needed to support the company. Process activity charts and other documents for the company, given each document a suggested place to stay in the office and manufacturing processes.

5.   An office-manufacturing guidebook was developed. In this guidebook, the methodology to transform SME companies is described. It has a guide to implement a lean information management system, and a lean manufacturing system.

5.3 Future Research

From the results of this research, it is expecting to prove this methodology extensively making more companies for its implementation, and verify its effectiveness.

All kind of SMS companies would use this methodology to enhance productivity, and transform their companies to lean. Ecuador is intending to substitute imports, now more than ever, needs this kind of research to transform its companies and be more competitive.

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APPENDICES