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Reducing Delays in Delivering Garments using DMAIC-Six Sigma Methodology

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ABSTRACT

In the apparel industry there is nothing more crucial than making the shipment dates. Therefore, delivery delays are considered as critical to quality for their negative affects on both customer satisfaction and financial benefits. Alsico, a multinational Belgium company specialized in work wear garments, is now forced to balance between goals that may conflict, mainly providing high-quality products, on time, and at reasonable price while maintaining manufacturing costs down. The project report proposes a method for analyzing a process in a garment manufacturer. By applying DMAIC Six Sigma methodology, Alsico's factories in Tunisia expect to identify key root causes of delivery delays. The project report outlines a method for defining, measuring, analysing, improving, and controlling the delivery metric, and illustrates this process with an example.

Keywords: Six Sigma Methodoly, Garment, Delivering

INTRODUCTION

Lean Six Sigma is an approach focused on improving quality, reducing variation and eliminating waste in an organization. It is the combining of two improvement programs, Six Sigma and Lean Enterprise [5]. Six Sigma is both a philosophy and a methodolgy that improves quality by analyzing data with statistics to find the root cause of quality problems and to implement controls. Statistically, Six Sigma refers to a process quality measurement and the nearest specification limit is at least six times the standard deviation of the process [4]. These days, the application of Six Sigma can be found in areas ranging from facility management and maintenance functions [10], online market research [16], supply chain improvement [12], such non-manufacuturing areas as healthcare management [15], managerial accounting [1], and human resources management [18]. The formulation and identification of useful theories related to Six Sigma development have also been proposed [14]. The foundation of the Six-Sigma program is statistics; sigma stands for standard deviations from the mean of a data set in other words a measure of variation, while Six-Sigma stands for six standard deviations from the mean [13]. Claimed that people in industries from manufacturing to service are witnessing the growth of a strategic continuous improvement concept called Six-Sigma [7]. Six Sigma is a business improvement strategy used to improve profitability, to drive out waste, to reduce quality costs and improve the effectiveness and efficiency of all operational processes that meet or exceed customers' needs and expectations [2]. Product Design is a process of creating new product by an organization or business entity for its customer. Being part of a stage in a product life cycle, it is very important that the highest levels of effort are being put in the stage [17]. Pointed out many components of successful Six-Sigma implementation as upper management support, organizational infrastructure, training, tools, link to human resource based actions measurement system and information technology infrastructure [8]. Highlighted that continuous improvement techniques are the recognized way of

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making significant reduction to production costs [9]. Concluded that the objective of Six-Sigma is to reduce the variation in the process and also defects of the final product [6]. The basic Lean concepts are the relentless elimination of waste through the standardization of processes and the involvement of all employees in process improvement [3]. Lean can be described as a set of principles and techniques that drive organizations to continually add value to products or services by enhancing process steps that are necessary, relevant, and valuable while eliminating those that are not. In recent years, Lean has been adopted by various service sectors, such as healthcare institutions [11].

In the last few years, it has become clear that Tunisian apparel industry faces many challenges, such as changing customer expectations, technological advances and particularly increasing competition. Today, more than ever, customers are demanding higher-quality, on time, and at reasonable price. For that reason, quality and customer satisfaction have become a focus of nearly every apparel manufacturer. Furthermore, competition, from Asian countries like China, is increasingly affecting the local apparel manufacturing environment. In fact, Chinese articles recognize a growing demand in Tunisian markets for their lower prices. Tunisian apparel manufacturers are now forced to balance between goals that may conflict, mainly providing high-quality products while maintaining manufacturing costs down.

Tunisian factories of Alsico are facing problems in delivering orders at the planned time which causes lost sales and customer dissatisfaction. The required lead-time for each order production has not been well controlled, and time-tables have not shown the most efficient sequence of production ensuring that the necessary materials and labor are in the right place at the right times. In order to reduce or eliminate delivery delays, a Six Sigma project was initiated and a Team was chartered with using Six Sigma strategy to determine the cause of the problem and implement suggested solutions. The emphasis is to determine and prioritize causes of delays, and to suggest a plan of potential solutions

PROBLEM STATEMENT

Alsico's Tunisian factories current situation

The environment in which Tunisian production facilities of Alsico operates today is very different from the one in which it has historically succeeded.

Labor-intensive, small-sized orders, frequently changing styles, and shorter lead times, added to changing customer expectations, technological advances, and particularly increasing competition, has clearly affected productivity, quality, and in consequence has decreased financial benefits.

Delivery delays

In the apparel industry, every delay in delivering orders to customers will badly influence the credibility of the company. In fact, customers must have their orders on time, and every delay will make them feel that the company is not as competitive as to produce garments with a time manner. Delivery on time is one of the key requirements of the customer.

Tunisian factories are clearly facing problems in delivering orders at the planned time. The required lead-time for each order production has not been well controlled, and time-tables have not shown the most efficient sequence of production ensuring that the necessary materials and labor are in the right place at the right times.

In recap, delays in delivering orders are critical to quality defects for their negative effects on both customer satisfaction and financial benefits. They are closely related with the efficiency of the Supply Chain involving the Production process and the logistic organization.

In order to reduce defects (delivery delays) a Six Sigma project was initiated. The emphasis is to meet customer satisfaction, to reduce costs and lead-times and to improve delivery performance.

SIX SIGMA PROJECT

A business comprehensive improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on outputs that are of critical importance to customers.

Six Sigma is a new way to manage an organization. It became a new way of doing things through the entire organization. This task is vastly more different than simply improving control of the assembly process. It's a methodology which drives industries to produce and design goods and services at Six Sigma level.

DMAIC refers to a data-driven quality strategy for improving processes and it's an integral part of the company's Six Sigma Quality Initiative. DMAIC is an acronym for five interconnected phases: Define, Measure, Analyze, Improve, and Control.

***D**efine phase:* The goal of this phase is to define the strategic direction of the organization, develop the problem statement, identify the team, define the resources, evaluate the key organizational support, develop the project plan and milestones and develop the high level process map.

***M**easure phase:* This phase set measures for the strategic objectives of the organization, define defect and opportunity, detailed process map of appropriate areas, develop data collection plan, validate the measurement system, collect the Data and determine process capability and Sigma Baseline.

***A**nalyse phase:* The aim of this phase is to define performance objectives, identify Value/Non-Value Added Process Steps and identify sources of variation.

***I**mprove phase:* The objective is to identify the opportunities for improvement and convert them to Six Sigma projects for improvement, perform design of Experiments, develop potential solutions, define operating tolerances of potential system and validate potential improvement by Pilot Studies.

***C**ontrol phase:* Set up a management control action of continuous reviews on the improvements made on the Six Sigma Projects. The goal is to define and validate monitoring and control system, develop standards and procedures, implement statistical process control, determine process capability and develop the transfer.

THE APPLICATION OF DMAIX-SIX SIGMA METHODOLOGY

Define phase

In the Define phase, the Six Sigma project team identifies a project based on business objectives and the customers of the process and their needs and requirements. The team identifies Critical to Quality Characteristics that have the most impact and creates a map of the process to be improved. Key deliverables of this phase are customers, their expectations and their requirements.

The Define phase components indicated in the previous section a full understand of the project outcome Y. It expresses the Y as a measurable process metric that tells how well the process is performing today and how performance should be after process improvement. However, in order to reach this clear definition of the Y, the voice of the customer (VOC) and a SIPOC diagram are needed. The voice of the customer helps to define a measurable project Y by translating unspecific customer requirements into measurable critical-to-quality elements.

In addition, VOC is used to verify the importance of the Y metric and to set specifications for the Y under consideration. The SIPOC (suppliers, inputs, process, outputs and customers) diagram clearly links the project Y to the process output. The output column of the SIPOC shows which Y is a result of the process.

After reviewing the role and the importance of each step in Define Stage, the team is formed, supported and committed to work on the improvement project. The first step is to identify high impact characteristics.

Voice of the Customer VOC

Before defining the process defects, units and opportunities, project team need to understand the needs of the customers. Voice of the Customer is the process of gathering customer comments/quotes and translating them into issues and specifications. From these comments, issues and specifications become the customer CTQ (Critical To Quality). It's a product or service characteristic that must be met to satisfy a customer specification or requirement.

To gather customer quotes, project leader developed a questionnaire and send it to workshops customer Alsico. This questionnaire is composed from several questions about current workshops performance.

Table1. *Voice Of the Customer VOC*

VOC QUESTIONNAIRE	
To: **Company:**	**Email:** **Tel.Nber:**
Function:	
What do you think about our delivery performance?	○ Unsatisfied ○ Little Satisfied ○ Satisfied
What do you think about products quality?	○ Unsatisfied ○ Little Satisfied ○ Satisfied
What do you think of our reactivity following the modifications or complaints?	○ Unsatisfied ○ Little Satisfied ○ Satisfied
What do you think of the welcome and the telephonic exchanges?	○ Unsatisfied ○ Little Satisfied ○ Satisfied
What are our strong points?	**What are our shortcomings?**
……….	………..

This questionnaire presented in table 1 illustrates how much the customer is feeling very upset about the respect of delivery dates.

Project Plan

The objective of this step is to develop a detailed project plan. That includes: milestones, tasks, deadlines and resources for each task.

A developed project plan will allow Project leader schedule DMAIC phases. It displays the work breakdown structure; total duration needed to complete tasks, as well as the percentage of completion.

The planning phase consisted of developing a master schedule plan using Microsoft® Office Project Professional 2003. This software offers a wide variety of powerful tools that lead to the better project schedule. To plan a project using MS Project user must follow several steps.

1. Defining the project by indicating estimated start and end points.
2. Identifying resources; both human and material resources (table 2).

Table2. *Resources used*

	Resources
Human	Black Belt
	Master Black Belt
	Technical Data Provider
	Logistical data provider
	Accounting and Finance data provider
	Planning and cutting data provider
	Master BlackBelt 1
	MasterBlack Belt 2
Material	Ms Visio
	Ms Project Pro
	Statsoft Statistica

3. Defining work period for different human resources.

4. Defining and organizing different tasks during each step of the DMAIC process.

5. Affecting the estimated duration for each task with the appropriate resources.

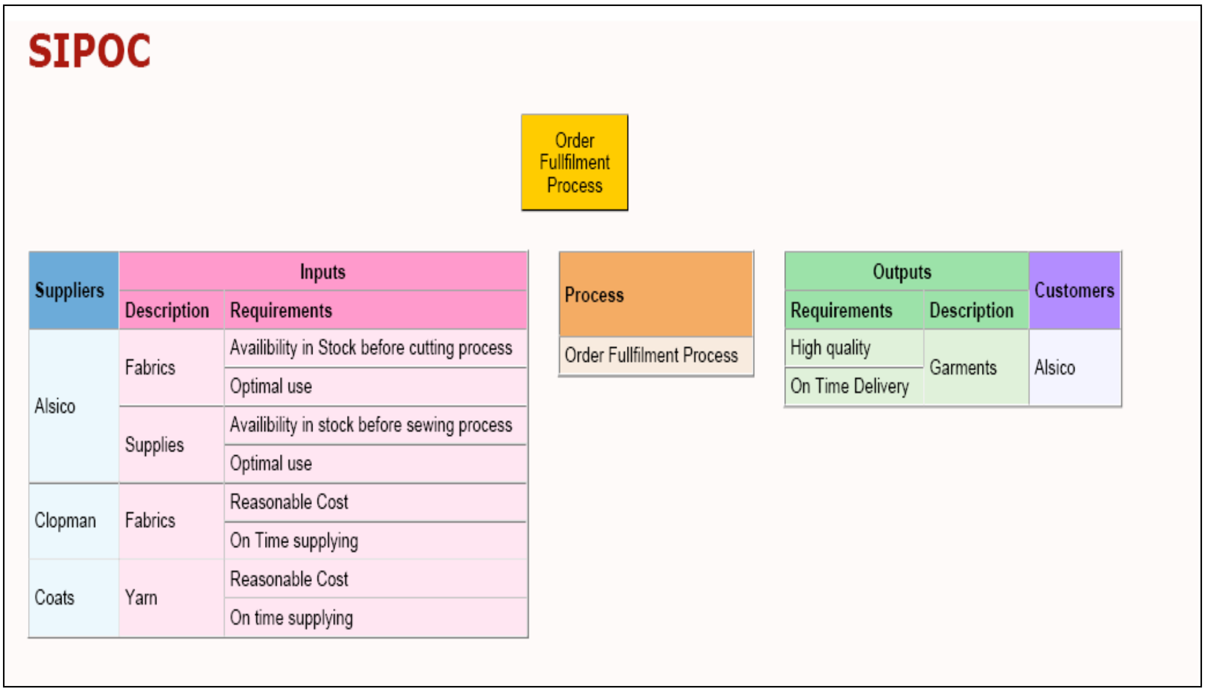
6. Finally, MS Project Pro generates the Gantt Chart for a visualisation schedule of the project.

Before the team explored the current situation in their areas, created a vision and an action plan to accomplish different tasks, they need to value the process in question.

SIPOC Diagram

A SIPOC diagram is a tool used by the team to identify all relevant elements of the order fulfillment process improvement project before work begins.

SIPOC stands for suppliers, inputs, process, output and customers. We obtain inputs from suppliers, add value through your process and provide an output that meets or exceeds your customer's requirements.



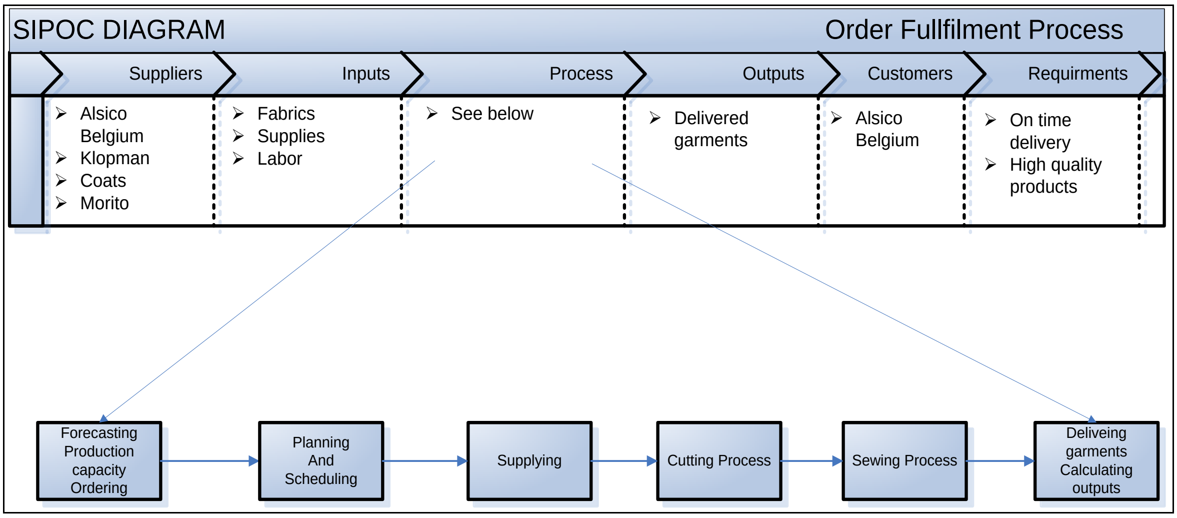


Figure1. *SIPOC Diagram*

Upon completion of the Define phase, the Leadership team's mission had basically been planned. The "Plan package" for Measurement phase was ready, providing the necessary documentation for facilitating the improvement process.

Measure Phase

In order to understand the logical flow of the DMAIC methodology and the relationship between each step, we continue referring to the Y=f(X) concept of DMAIC. While in the Define phase was identified what project Y outcome, the Measure phase aims to measure Y and its inputs Xs.

Process Mapping

Process mapping is a tool that is used to understand, analyse processes and activities in an organisation and assist in identifying opportunities for improvement. It is clear that the focus of this tool is the process.

A process is defined as a series of related activities that "flow" through an organisation, not limited to a single function or department and something that can be viewed from end to end. The general workflow of a business process is presented in the following chart.

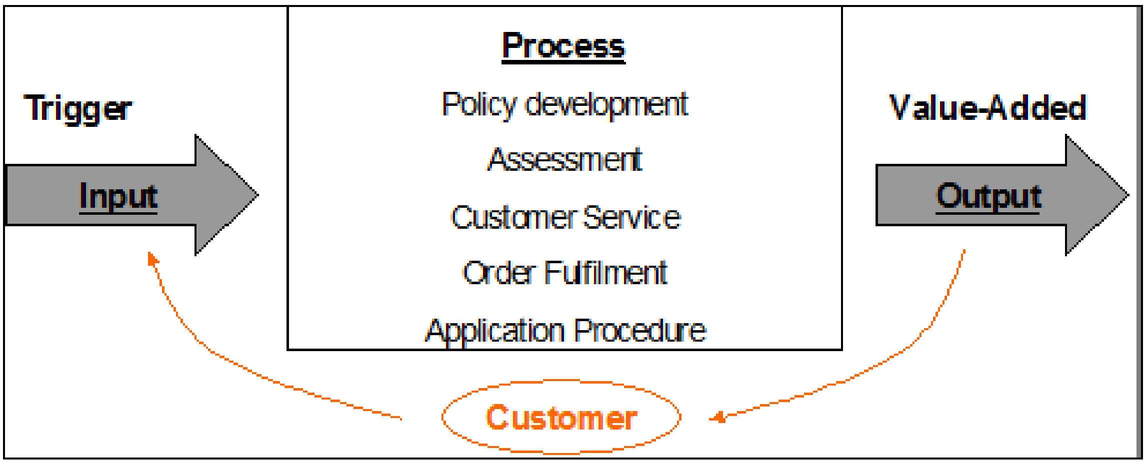


Figure2. *The process chart*

As application, figure 3 presents a high level flow chart of the Order Fulfilment Process in Tunisian workshops.

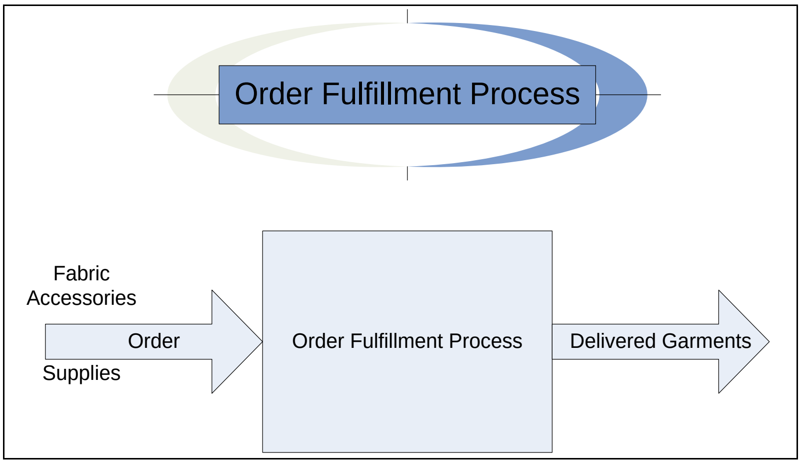


Figure3. *Order Fulfillment Process flow*

Flowcharting

As we have the high level view of the process, typical reasons for conducting process mapping include the complexity of processes, especially in clothing manufacturing and lack of understanding constrains management's attempts to improve processes.

The most important tool in the process mapping is flowcharting. A flowchart is a graphical representation of a process, depicting inputs, outputs and units of activity. It represents the entire process at a high or detailed level of observation, allowing analysis and optimization of workflow.

In simplified words, flowchart is a diagram that uses graphic symbols to depict the nature and flow of the steps in a process. Another name for this tool is "flow diagram."

Flowcharting helps the team and others involved in the process to understand how it currently works by using simplified symbols and three levels considering how the flowchart will be used and the amount and kind of information needed by the people who will use it. Following viewgraphs shows common symbols used and present, with an example, different levels of flowcharts.

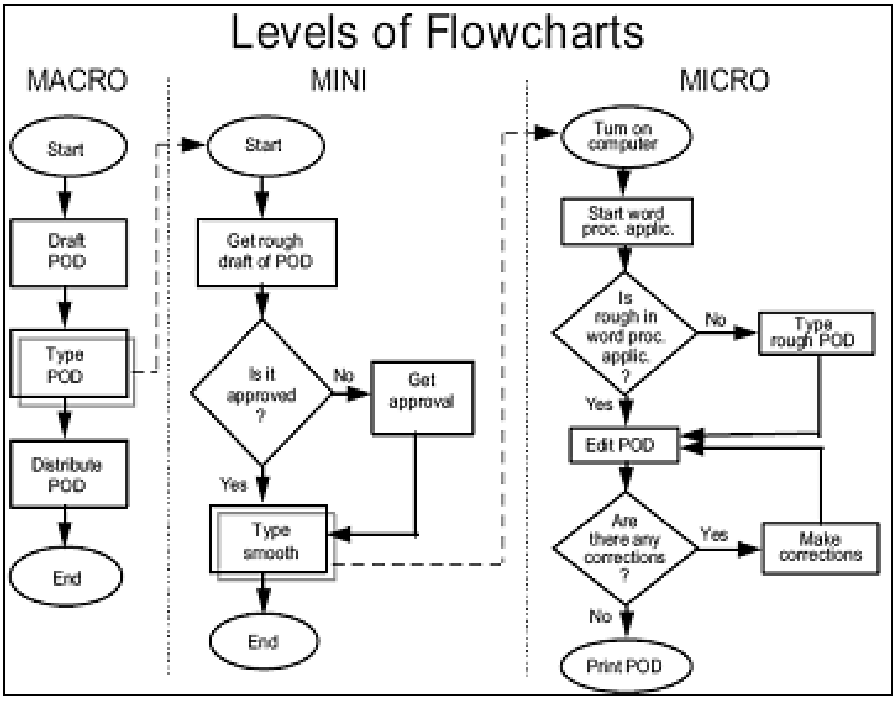


Figure4. *Levels of flowcharts*

However, developing a process map requires more than information about symbols and levels, it is a sequence of key steps to achieve a better deployment of this improvement tool.

Mapping the Order Fulfillment Process (OFP)

The label used is not important. What matters is that the team members constructing a Flowchart understand how the information is going to be used and the people interpreting the chart understand the level of detail it presents. For that reason, it was necessary for team leader to build up several steps ensuring the involvement of team members in the mapping process.

In this way, identifying flowcharting and mapping the process is a more rational and realistic exercise.

1st Step: The order fulfilment process selected, team leader walks the floor, following both; the material and the information flow. In this step, project leader include different non-value added steps, those steps which causes waste of materials, time wait, non quality tasks, etc.

2nd Step: Team Leader starts with drawing a high-level flow (Context Diagram) of the OFP. It presents the "big picture" of the process.

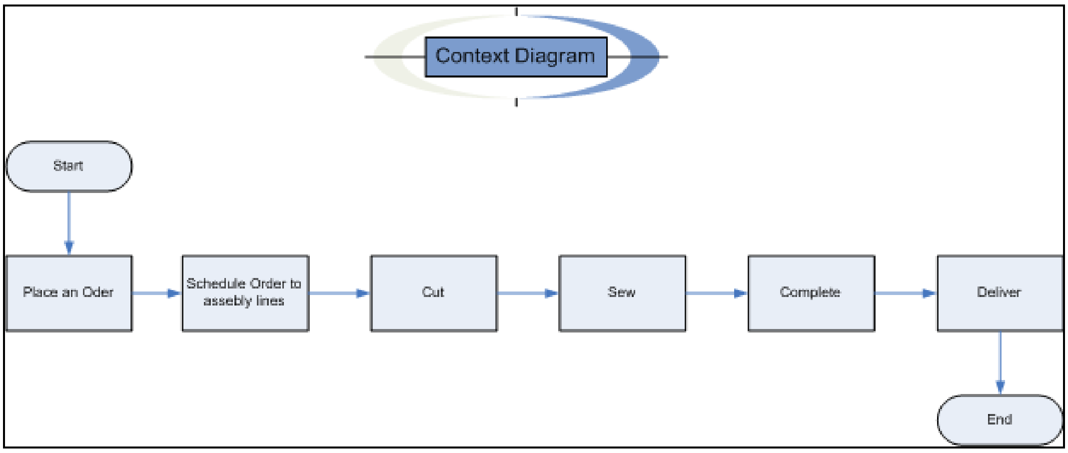


Figure5. *Context Diagram of the OFP*

3rd Step: Team Leader walks the floor, discusses with team members and process owners about process mapping advantages. He also explains to them how it is important to a process owner to graphically present the flow of the process, to see different inputs and outputs, to evaluate the non-added value steps, and to discuss about improvement opportunities.

The previous diagram shows that there are three major Sub processes; placing and scheduling orders process, cutting process and sewing process.

4th Step: Every process owner defined the beginning and end of the sub process. Second, he defined key inputs and outputs. Third, he walked through each key sub process step by step underlining different non-added value steps. Finally, he drown the process as it is works.

5th Step: Project Leader assembles different diagrams from process owners and creates them using *Microsoft® Office Visio Professional*.

The process design is the most important part of the process improvement exercise, Master Black Belts guided project leader to how elaborate "a cross functional flowcharts".

Following figures illustrate process flowcharts for each sub process of the OFP. Steps coloured in yellow are defined as non-value added steps.

6th Step: Project Leader develops a Value Stream map for the process. The Value Stream Map takes into account not only the activity of the product, but the management and information systems that support the basic process.

7th Step: Project Leader distributes process flowcharts to team members, and conducts a meeting which aims to interpret diagrams.

Table 4 enumerates different causes of delays in the supply chain that team members picked from process maps.

Table3. *Causes of delays*

Sub Process	Causes of Delays
Cutting Sub Process	Wait time for *.mdl files from Alsico Supplying Fabric when it is unavailable in stock Supplying Accessories when it is unavailable in stock Supplying embroidery parts
Sewing Sub Process	Supplying Fabric from the cutting room Supplying Accessories from the cutting room Low production yield in assembly lines High Absenteeism in assembly lines Reparations and rework time

Data Collection Plan

Once main causes of delays were identified by team members, Black Belt should develop a data collection plan in order to gather data in the measurement phase; it is essential that the team collect and produce a valid and reliable set of numerical facts to properly understand their situation.

There are several crucial steps that need to be addressed to ensure that the data collection process and the measurement system are stable and reliable. Incorporating these steps into a data collection plan will improve the likelihood that the data and measurements can be used to support the ensuing analysis. These steps aim to answer to some important questions before initiating the data collection effort.

- Why collect the data – what do you want to know?
- What method will be used for analysis?
- What data will be collected?
- Who will collect the data?
- How will the data be measured?
- When will the data be collected?
- Where will the data be collected – who and what is your data source?

Analyse Phase

Through analysis, the team can determine the causes of the problem that needs improvement and how to eliminate the gap between existing performance and the desired level of performance. Following the Y=f(X) concept of Six Sigma, Analyze phase aims to quantify X's and to identify Xs and Y relationship.

The main objective of this phase is to analyze the data collected to determine root causes of defects and opportunities for improvement.

1. Identify gaps between current performance and goal performance.
2. Identify sources of defects.

Once data collected, Project Leader has the responsibility to analyze data using *Statistica* software, which provides a wide range of statistical and graphical application for data analysis.

At this stage, Master Black Belts and project advisors helped project leader determining the appropriate analytical tool for each metric.

Analyzing the planning and the scheduling in the workshop is primarily essential to clearly characterize the input, at the same time having an overview on *Statistica* applications.

Table4. *Frequency Distribution of Run types in the workshop*

	Count	Cumulative Count	Percent	Cumulative Percent
short	8	8	8,24742	8,2474
Long	1	9	1,03093	9,2784
very short	77	86	79,38144	88,6598
Medium	11	97	11,34021	100,0000
Missing	0	97	0,00000	100,0000

Improve phase

Once problem causes are determined in the Analyze phase, the team finds creative new improvement solutions. More often than not simple process experimentation and simulation bring the team big gains in this step.

The team also identifies what will happen if needed improvements are not made and what will happen if the improvements take too long.

The improve phase is closely related to the Y metrics of the process; in fact, the emphasis of this phase is to identify solutions to improve Y.

The ongoing focus of this phase is to create innovate solutions using technology and discipline and to develop and deploy implementation plan.

Consequently, the main goal of this phase is providing Designers and Developers of the new ERP system with improvement solutions that may be integrated further in the design and development of the ERP system. These solution must be directly addressed to X's metrics.

Scheduling Procedure Generated by Alsico

Externally, the ERP system must include an application that checks the availability of resources before planning creation. This application must guarantee that complete resources are available for all planned orders. Project Leader proposes the Functional design of this application.

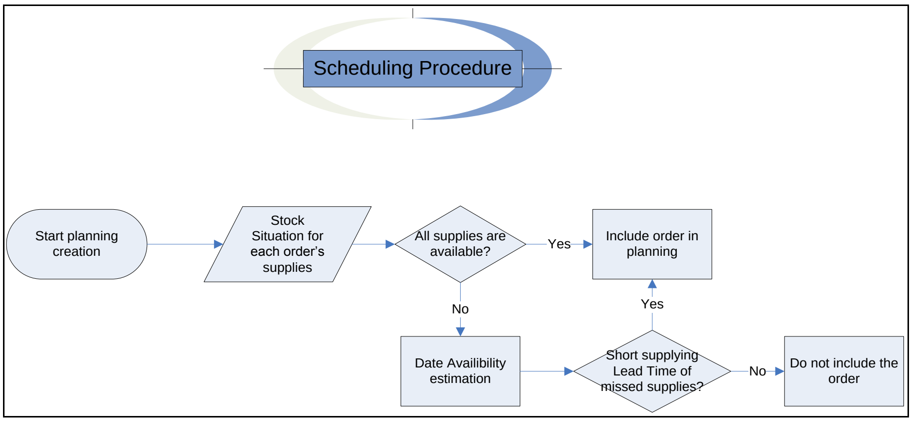


Figure6. *Functional design of scheduling procedure*

Scheduling procedure generated by Tunisian factories

Tunisian workshops can also play a vital role in scheduling. When implemented, a scheduling procedures generated by workshops would have many advantages.

First, it ensures the involvement of the factories personnel in the product life cycle, especially in planning and resources management.

Second, it helps Alsico personnel to share decisions with Tunisian personnel who can consider decisions in light of the current production process situation.

Finally, monitoring the production scheduling in Tunisia eliminates wait times in taking the right decisions, minimizes the number of non-added value steps, and drives the factories to monitor all the garment life cycle.

The balance of these reasons justifies the introducing of scheduling procedures in Tunisian factories.

As part of this activity, Project leader suggests an ERP integrated application based on a Pull system. Pull systems and their implementation are explained in more details in the next section.

At this stage, we present a basic component of the pull system which is associated with our desired scheduling procedures; a triage system for determining which incoming order should be released into the next planning.

In scheduling, the question is which order would be released into the process (cutting or sewing). Some orders must be prioritized while others were much less likely to be accepted, represented uncertain situations like resources unavailability.

The answer lay in triaging the orders. Each order is rated on a scale of 1 to 3 on each of these criteria:

- Model files availability; *mdl files
- Fabric availability
- Accessories availability
- Order urgency level
- Order Size

Table5. *Description of the Pull system*

	1	**2**	**3**
***.mdl files availability**	Not available		
Fabric availability	Not available and have long lead time	Not available but short supplying lead time	Available
Accessories aavailability	Not available and have long lead time	Not available but short supplying lead time	Available
Order urgency level	Not urgent	Urgent	Very Urgent
Order Size	Long run	Medium run	Short run

The scores for each criteria were added together for each order. Those with the highest scores would be the next to be released into the process. In other words, an order that scored a 9 would be planned and produced before an order that scored a 6.

In order to perform this application, it is useful to sort in the planning according to these orders characteristics:

- Style: orders that have the same style will be planned then sewed in succession in assembly lines, it minimize wait times in changing layouts when changing the styles.

- Model: same models of the same style will enter into the process in successions.
- Colour of Yarn: it is very important to sort the orders according to the main colour of yarn used to sew the garments. This helps to minimize movement of workers in assembly lines.

Pull system development

Pull Systems control the flow of resources in a production process by replacing only what has been consumed. They are customer order-driven production schedules based on actual demand and consumption rather than forecasting. Implementing Pull Systems can help to eliminate waste in handling, storing, and getting the product to the customer. Pull Systems are an excellent tool to use in the areas where flow manufacturing can not be achieved. Pull systems are addressed to Lead time metrics. Before presenting the pull system components it is constructive to underline the impact of lead times in the order fulfilment process.

Lead Time and WIP

As defined in previous sections, the lead time of any process is amount of time taken between the entry of work into a process and the time to completion process. In mathematical description:

$$\text{Total Lead Time}=\frac{\text{Number of Things in Process}}{\text{Average Completion Rate}} \quad (1)$$

The number of things in process is the work that the customer has requested of the workshops. One of the core principles of Six Sigma is that you have to reduce TIP if the factories want to stand a chance of delivering work faster and reducing waste in the processes.

The most common word to describe the TIP is WIP: the Work In Process. For example; the number of work in process in the sewing process is the amount of orders or garments that came from the cutting room. In the same way, WIP for the cutting room is the amount of orders in the planning to be cut.

Reduce WIP using Pull System

The factories reduce WIP and improve speed by setting up what is known as a "pull system." The essence of a pull system is that work enters a process at the same rate at which it exits. Since the "exit rate" is controlled by customer demand that means the process is paced to meet the customers' needs.

Here an illustrative example; Table 6 presents the WIP (number of orders in the sewing process) rate in the workshops during the measurement activities.

Table6. *WIP in workshops*

	Count	Cumulative Count	Percent	Cumulative Percent
April 20	1	1	1,03093	1,0309
April 25	9	10	9,27835	10,309
April 26	55	65	56,7010	67,010
April 27	2	67	2,06186	69,072
April 28	5	72	5,15464	74,226
April 30	11	83	11,3402	85,567
May 2	7	90	7,21649	92,783
Missing	7	97	7,21649	100,000

According to Table 7 the workshops received 55 orders on April 26 and only 1 order on April 20. This shows that there is a total absence in production capacity management.

If we admit that the average completion rate of the workshop is 10 orders/day, then the lead time to accomplish 55 orders will be 5 days and a half. To reduce the lead time we have to reduce WIP.

Determining this cap on the amount of work in process is the key element in a pull system. The next step is creating an input buffer or bin. The bin can be an electronic database integrated to the new ERP system.

Once the planning is created using the first component of the pull system which is sorting application, the program calculated the average completion rate of each assembly line based on average Absenteeism and Yield, then it enters to the process (cutting then sewing process) the managed WIP.

Integrating such a pull system will control and then reduce the WIP, thus eliminating the non-value ass cost driven by those things in process. However, implementing the pull system must be deployed using Kanban.

Pull/Kanban Deployment

The output of the Pull system is a list of orders that are addressed to specific assembly line including information about each order and lead time. This list must be given to all personnel in the cutting room and the workshops to have the clearest idea about "what we will work?".

At this stage, several questions must be addressed:

- How to follow the workflow of the orders?
- How to control key metrics in the workshop, like Absenteeism and yield?

Project Leader suggests the deployment of Kanban in the factories. Kanban cards will be an output of the Pull system computerized application.

After printing the list of orders (as sub-planning) and distributed to cutting room and workshops managers, the computerized application print a Kanban for each order. The Kanban will be an order-addressed card that contains general information about the order and the rank of the order in the process.

State 1 **Order 472472 Rank 4** **Style Jacket** **Model A8817035** **Assembly Line W1** **Delivery Date 06/23/2015** **Date**	**State 2** **Order 472472 Rank 4** **Style Jacket** **Model A8817035** **Assembly Line W1** **Delivery Date 06/23/2015** **Date**
State 3 **Order 472472 Rank 4** **Style Jacket** **Model A8817035** **Assembly Line W1** **Delivery Date 06/23/2015** **Date**	**State 4** **Order 472472 Rank 4** **Style Jacket** **Model A8817035** **Assembly Line W1** **Delivery Date 06/23/2015** **Date**
State 5 **Order 472472 Rank 4** **Style Jacket** **Model A8817035** **Assembly Line W1** **Delivery Date 06/23/2015** **Date**	**State 6** **Order 472472 Rank 4** **Style Jacket** **Model A8817035** **Assembly Line W1** **Delivery Date 06/23/2015** **Date**

Figure7. *Example of Kanban deployment*

This paper is the output of the computerized Pull/Kanban for every order planned. Each card in this paper represents Kanban for each step in the order fulfilment process.

- State 1: Order planned
- State 2: Order cut
- State 3: Order delivered to workshop
- State 4: Order launched
- State 5: Order sewed
- State 6: Order packed in the box

After each process step, sticked Kanban card will be removed from the paper then putted into box. This system will allow any manager to check the current situation of the process simply by checking the box which contains Kanban cards. At any moment, the flow of material is easily controlled and the real state of any order is monitored.

As a conclusion, Pull/Kanban system implementation focuses on scheduling and supervising the production runs. However, improvement opportunities look wider and other tools may be applied to improve delivery performance.

Routing procedures in sewing workshops have to increase productivity and cut unnecessary costs. Thus, routing orders through the assembly lines is an important opportunity while setting up the improvement action plan.

However, when applied improvement activities cannot be effective without a control that ensuring that the key metrics remain within the acceptable ranges over time so that process improvement gains are maintained.

Control Phase

This phase aims to control the improvements to keep the process on the new course. In the Control phase, tools are put in place to ensure that the key variables remain within the acceptable ranges over time so that process improvement gains are maintained. The team develops a project hand off process, reaction plans, and training materials to guarantee performance and long-term project savings.

Objectives

The general objectives of this phase are:

- Prevent reverting back to the "old way".
- Require the development, documentation and implementation of an ongoing monitoring plan.
- Institutionalize the improvements through the modification of systems and structures.

Owing to Master Black Belt suggestions, the work of project leader consists on providing propositions that will be further integrated in the development of the ERP system.

Statistical Process Control Deployment

Statistical process control is the application of statistical methods to identify and control the special cause of variation in a process.

Statistical Process Control (SPC) is the equivalent of a histogram plotted on it's side over time. Every new point is statistically compared with previous points as well as with the distribution as a whole in order to assess likely considerations of process control (i.e. control, shifts, and trends). Forms with zones and rules are created and used to simplify plotting, monitoring and decision making at the operator level.

Statistical Process Control in Statistica

SPC uses such basic statistical quality control methods as quality control charts. According to precedent stages, we can obviously remark that *Statistica* have many advantages and shows with the different Control Charts the efficacy to do a better control of the Order Fulfilment Process metrics, especially to control Metrics related to lead times and production indicators such as Absenteeism and Yield in assembly lines.

Linking ERP system development and SPC

A team of computing engineers in Berco – Belgium. Tunisia, is currently in the process of developing the ERP system for Alsico. The development process includes modifying an existent computerized system and involves Analysis, Design and Implementation.

As a complement to the tools deployed in the improvement phase, it is necessary to integrate applications that control different measured metrics; the Pull/Kanban system computerized application must be followed by a control application.

So, that's why it is valuable to integrate SPC in the implementation of the ERP system. This integration requires computerized tools to perform analyses and displays control charts. Thus, the use of *Statistica* will be very appropriate.

CONCLUSION

The DMAIC Six Sigma process proposed in this project was used to identify, measure, and Analyze key metrics related to delivery delays.

Different points are offered as key lessons learned from this work such as:

- Do not underestimate the importance of measurement. While knowledge and experience are extremely important, without measurement it is impossible to synthesize the data into useful information to support decisions.
- People make it happen. Measurement is necessary but not sufficient. Participation from people across the organization facilitates and enhances the data collection process.
- DMAIC projects require communication amongst and between the operators and the functional support personnel to support rapid problem solving. The culture of an already existing shop may not support the kinds of interactions and relationships in the garment manufacturing. Managers should be aware that the introduction of Six Sigma projects can potentially require changes to the organizational culture.

The vision and goals of the organization need to be communicated not only through the words, but also reinforced through the actions of the organization's leaders and through the incentives offered to the employees.

Another important challenge in a manufacturing organization is the need to understand and manage capacity. Although ERP system has been immensely useful in the manufacturing environment, they are not able to support many of the capacity loading decisions that are made on a day to day basis. Managers need to develop the skills within the organization to manage capacity as effectively as possible given the tools available.

Capacity planning in a manufacturing environment is a complex problem, but the success of a manufacturing organization is tied to its ability to match the required resources to the available capacity as efficiently as possible.

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