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TITLE: Proposal of a Lean Six Sigma methodology implementation in a Service Process.

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Títol: Proposta d'una implementació de la metodologia Lean Six Sigma en procés de serveis.

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Resum

L'objectiu principal d'aquest estudi és proposar millores per als processos en un Departament de Serveis, utilitzant la perspectiva del Lean Six Sigma, el que podria reduir significativament el temps de resolució d'incidències i augmentar el nivell de satisfacció del client, aconseguint importants millores en el rendiment d'aquesta empresa.

Els objectius generals son, per tant, validar que es pot aconseguir l'aplicabilitat de Lean Six Sigma en aquest Departament de Servei i dur a terme una revisió en profunditat dels processos de Gestió d'Incidències que es podrien millorar.

Aquest projecte es basa en les dades empíriques obtingudes com a part de la ERP per aquesta empresa en diversos fabricants de cartró. L'anàlisi de dades es basa també en l'observació i les entrevistes semi-estructurades amb els empleats que treballen en aquest Departament. L'objectiu és aconseguir millores utilitzant com a referència les implementacions anteriors dels eines i tècniques teòrics de Lean Six Sigma en altres Departaments de Servei.

Paraules clau: Metodologia Lean Six Sigma, Departament de Serveis, Gestió d'Incidències

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Overview

The main goal of this study is to propose improvements for processes in a Service Department of an ERP company, using the perspective of the Lean Six Sigma, which could reduce significantly the time in solving incidences and increase the level of customer's satisfaction, achieving important improvements in the performance of this company.

The general objectives are, therefore, to validate that is achievable the applicability of Lean Six Sigma in this Department and to perform a depth review in the Incident Management processes that could be improved.

This project is based on empirical data obtained as a part of the ERP implemented by this company in several cardboard manufacturers. The data analysis also will be based on observation and semi-structured interviews with employees working in such department. The aim is to achieve improvements using as reference previous implementations of the theoretical Lean Six Sigma tools and techniques in other Service Departments.

Keywords: Lean Six Sigma methodology, Service Department, Incident Management

Dedication

I lovingly dedicate this thesis to my fiancée Rosa, who has been my love and support in each step of the way.

This thesis is dedicated to my parents, Ramón & Graciela, who have supported me all the way since the beginning of my studies.

-The real world is the loving thoughts on our mind–

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INTRODUCTION

After understanding Lean and Six Sigma tools and techniques, this project will analyze the implementation of both methods in the service sector through literature review, and analyzing the empirical data in a Service Department of an important company in cardboard sector, called Rboard; it will determine the process improvements that can be made through Lean Six Sigma and improve the time and quality of the response to their customers.

Despite the fact of the increase in productivity of employees, the Service Department of Rboard's Company is not offering quality services to customers. The objective of this study is exploring the process of implementation of Lean throughout all the levels of Service of the organization, analyzing to which organizational factors can enhance or impede this process. The thorough review of the literature aims to bring out the challenges that companies are facing in the process of implementing Lean Six Sigma approach as well as some to determine limitations and barriers of the model.

The main goal of this study is to propose improvements for processes in a Service Department of this ERP Company, using the perspective of the Lean Six Sigma, which could reduce significantly the time in solving incidences and increase the level of customer's satisfaction, achieving important improvements in the performance of this company.

For these reasons, this project aims to explore and understand Lean implementation in the company and the objectives intended are:

- To understand Lean techniques, applicable for Service Department.
- To identify Customer Services Functions and understand how Lean Six Sigma (LSS) concepts can be applied to improve processes.
- To identify the challenges that personal could face during LSS implementation and to identify the advantages of its application.
- After understanding LSS tools and methodology as well as companies services procedures about the management of information of technical incidences and requests, the personal will have empirical collected data to understand the process improvements that can be made through Lean Six Sigma.

The general objectives are, therefore, to validate that is achievable the applicability of Lean Six Sigma in this Department and to perform a depth review in the Incident Management processes that could be improved.

This project is based on empirical data obtained as a part of the ERP implemented by this company in several cardboard manufacturers.Hence, does not cover other departments within the complete organization or other similar companies. However, secondary data of several other Service Departments will be used as comparison to analyze the applicability of LSS. Therefore, it is not possible to generalize the results obtained from each particular case. The data analysis will be based on observation and semi-structured interviews with employees working in such Department. The aim is to suggest improvements

using as reference previous implementations of the theoretical Lean Six Sigma tools and techniques in other Service Departments.

This work is organized in 6 chapters. After the present introduction, Chapter 1 presents the prior and essential details that need to know about Lean Six Sigma theoretical concepts. There is a systematic literature review in order to be familiar with the topic based on different point of views of the main contributors for Lean theories. It presents the background and the importance of use Lean in service sector for each case. It also introduces the methodology, tools available and used, and studies of early implementations.

Chapter 2 is an identification of the measurable objectives of the improvements. Chapter 3 reviews the description of the company under study. Chapter 4 shows define and measure of the current state of the art in the process. In these chapters, both theoretical and practical methodologies have been applied.

Chapter 5 gives the analysis to the opportunities found to improve the process. Chapter 6 provides improvements in services processes designed for such company and steps recommended for future closure. Finally, the conclusions and limitations are at the end.

CHAPTER 1. LITERATURE REVIEW

Analyzing major objectives stated in Introduction, it is clear that there is a considerable amount of literature available regarding the use of Lean thinking and Six Sigma within the manufacturing sector, but relatively little regarding their use in the Service sector.

The purpose of this literature review is to examine, research papers, Web sites, journal articles, books and industry publications to provide an overview of Lean thinking and Six Sigma, identifying the major challenges that have faced authorities of Service Departments implementing these practices and examine their use in similar organizations.

1.1. The Lean concept.

Despite the term Lean, was coined by James Womack, Lean thinking originated within the Japanese automobile industry following World War II and is principally based on the Toyota Production System (TPS), which was developed by a production executive named Taiichi Ohno and was used to improve the quality and productivity within the Toyota Motor Company [2]. Lean later increased in popularity in the 1990s, after the publication of the bestselling book, *The Machine that Changed the World: The Story of Lean Production* (Womack, Jones, and Roos 1991), which chronicled how organizations could transform their operations by adopting the lean approach developed at Toyota. Lean has since been widely adopted across every manufacturing industry ranging from automobiles to electronics, and it is being increasingly applied to a wide range of governmental entities and lately private-sector service organizations. Lean has evolved as a management approach to improve all processes across the industry [4].

Manufacturing companies started to implement Lean by adapting similar practices in Service Departments within the organization because of positive results from Lean practices. In the study made by Bowen and Youngdahl (1998), it was shown that service sector could truly benefit from the adaptation of the theories developed for manufacturing sector. Also in [9] supported this argument by pointing out that in service sector, people valued faster service and Lean helped to eliminate waste from the value chain helping customer to receive the service immediately.

1.1.1 The Five Lean Principles

Organizations should focus on continuous improvement by using the five Lean principles to improve their operations [6]. These principles are described by Womack and Jones [10], such as specifying the value, the value stream, flow, pull and perfection, which are discussed in the following:

1. The first one is specifying the value from point of view of customer.

Manufacturing companies are likely to offer products that are convenient for manufacturers, rather than focusing on producing products that customers' will value. Therefore, they are challenged to develop product portfolio based on understanding customers' requirements, which leads to meet Lean principle to specify values.

2. The second one is identify and map the value stream, which means organizing processes from raw materials to final customer based on the viewpoint of customers, rather than what departments want, eliminating processes that do not add-value.

3. The third principle is to ensure product or service flowing continuously. This is about creating value flow that has to do with processes, people and culture, and it is used to reduce delays of value added activities and eliminate non value added activities.

4. The fourth principle is leverage pull-system between all steps in the value stream, which means elimination of excess production by focusing on the demands of customers, designing and providing what the customer wants only when the customer wants it.

5. The fifth principle is seeking perfection, which involves increasing quality, eliminating the root that causes waste, with a reasonable price, to achieve the ultimate goal of zero defects. This means that improvement cycle should be continuous and it should never end.

These are the five principles originally developed in manufacturing, but they can also be applied in service. Figure 1.1 shows the five principles, which are adapted for the Service Department under study. The second principle is the most important one, which emphasizes identification of the process that creates value for customer that can be achieved through "the value stream" in manufacturing and "Attending incidences" in Service. Remaining principles in service are the same as in manufacturing sector [10].

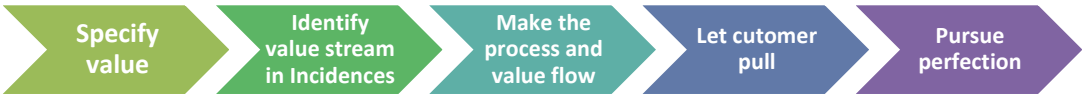

Fig. 1.1. The Five Principles of Lean for Services (Based on: [10])

1.1.2 Lean in Service Sector

In organizations, 80% of the costs come from product design, which includes services, such as finance, human resources and product development, while costs from manufacturing labor comprise only 20%. This leads to higher costs caused by services and with increasing competition, it will lead to loss of customers, which are more apparent in services than in manufacturing [6]. To keep customers satisfied, companies are trying to increase the service quality integrating Lean principle in order to reduce costs and increase profitability [11].

Lean concept is a way to identify where the value is in the process, eliminate the waste within the process and create value to the customer, which can be applicable in any organization, since the goal of organization is to create value to end customer. One development of Lean beyond manufacturing was application of Lean in the supply chain management. This helped the organizations to develop closer relationship with suppliers by sharing more information, increasing innovation and lowering the costs [6].

There are several characteristics of Lean service proposed by [11], which are shown in the next list. Some of them involve reducing the performance tradeoffs between the objectives of organization and customers; reducing set-up time and applying JIT; increasing customer involvement and offering training to employees and customers; as well as investing on people because they can make a difference in the business. Therefore, by focusing on Lean service, organizations give greater attention to the investment of people, rather than equipments [11]. This table will be used in later chapters in order to compare Lean characteristics with practices widely used in the RPM Company under study, in order to eliminate waste and improve flexibly react to customers' pull.

Lean Service characteristics:

1. Reduction of performance tradeoffs.
   Operations goals of both internally-focused efficiency and customer-defined flexibility
2. Flow production and JIT pull.
   Minimize set-up time allowing for smoother flow.
   JIT levels of both input and output.
3. Value-chain orientation.
   Apply service blueprinting and value analysis to eliminate non-value added activities.
4. Increased customer focus and training.
   Involve the customer in the design of the service package.
   Train employees in customer service skills and behaviors.
   Train customers in how to contribute to quality service.
5. Employee empowerment.
   Invest significantly in employees (skills, teambuilding and participation).
   Empower employees to leverage customers' value equation (benefits divided by price and other "costs").

Lean in Service Sector is essential to add value to customers by providing services with higher quality and speed the process by using fewer, but right resources. There is a need to analyze the non-value added activities to reduce the cost and complexity. Employees should identify the waste and hidden costs caused in different steps of processes, which might involve reorganization of companies by less capacity, material and people to perform the work more efficiently [6]. Also, organizations should focus on value added activities from customers' perspective. In this way, they will understand better the customers' needs and how much they are willing to pay to increase quality of service [6].

According to Womack and Jones [10], Lean thinking "provides a way to specify

value, line up value-creating actions in the best sequence (the value stream), conduct these activities without interruption whenever someone requests them, and perform them more and more effectively."

The key point for Lean theory is the elimination of all the waste within the processes [10]. Waste includes activities which do not add value to customers and organizations. For them, waste is a cost that they are not willing to pay. It is important to increase the awareness of employees on the concept of waste, as well as on the ways to identify and reduce waste. Fujio Cho of Toyota identified the seven types of wastes for which the companies face difficulties in identifying and reducing them [2]. To get a better understanding of the wastes in any organization, the seven types of wastes can be described in terms of manufacturing and service environment. For further information, see table 1, Annex 4.

1.1.3 Challenges in Lean implementation

Lean is a very important concept in organizations because it involves broad understanding, high commitment and deep analysis of problems. More and more organizations are implementing Lean in long term basis to improve quality, and also to reduce costs, fast delivery and efficient queue times. To succeed in Lean implementation, several authors agreed that a committed and involved management is necessary to give support to the organizations. Also, an external support might bring a new way of thinking and transfer knowledge to organizations by recommending the areas that Lean application is necessary. External support might be helpful in short term to increase the knowledge of organizations toward Lean; however, the organizations should not be dependent on them because it is a continuous progress that last long [12]. Therefore, organizations should be aware that Lean cannot be implemented overnight. There is a need to work continuously to reduce waste and increase commitments by looking at opportunities and limitations [12]. An example is Toyota that implemented Lean in 1950s and still continues to reduce waste [2]. This is the reason why it is important to understand further the challenges of Lean implementation.

Hence, top management commitment is important to give support to low level employees and convey consistent information about Lean. Also, increasing communication between employees, as well as within the management and employees, will benefit to implement Lean successfully. Furthermore, a clear communication plays important role in keeping strong customer-supplier relationship, where there are clear responsibilities of employees involved for products and services, and those in charge for responding to various problems and concerns.

The main challenge is the lack of standardized process within the service industry. [6] Points out that it is more difficult to identify processes within the service, because they are not as evident as in manufacturing. Also, due to the size and complexity, it is difficult for organizations to deal with processes to minimize the waste. Therefore, processes should be documented in order to

keep track of the performance continuously. [6] Also emphasizes the importance of following a procedure to keep track of process for services. Sometimes, it is hard to find fixed processes, which made it difficult to apply the value stream mapping and there are various stakeholders, who were not all supporting Lean principle.

Authors [11, 6] emphasize that Lean should engage all people from organization. This involves strategic changes because of the hierarchy's barriers. It requires low level of organization to be more empowered as they are the ones working in the operation, who can identify the waste easier. Then, the main challenge is empowering and providing the relevant training to the staff. Another challenge is that employees cannot keep track of process since they are not able to measure the time needed for different work items as there is uncertainty in task completion [11].This happens because employees have no control over their structure of tasks, which is the reason why processes are hard to define in service industry. However, employees should be aware that working by standardizing processes will give them more freedom and empowerment, as well as they will receive information about change management [11].

The author in [9] mentions the importance of managing employees' behavior and actions because Lean applicability depends on their mood in every day work; therefore, there is need to avoid their mistakes in processes. In service processes, the interaction of people has more significance, so they should not be treated as machines. For example, it is less complicated to reduce setup time in machine than reduce the time of call for sales employees. At the end, several authors agreed that identifying process that causes the waste is the biggest challenge in service setting for Lean implementation.

1.2. Six Sigma.

As seen, the Lean methodology is a relentless focus on understanding and increasing customer value, by reducing the cycle time of product or service delivery. Reducing the cycle time occurs by eliminating all forms of *muda*, which is a Japanese term for "waste," *muri*, which is a Japanese term for the "overburdening of people and machines," and *mura*, which is a Japanese term for "unevenness in the workflow or unevenness in demand."

Within the enterprise, these three concepts are linked in a circular fashion: which is waste causes unevenness, which causes overburdening that causes waste, and so on. Therefore, it is important to deal with all three concepts to improve the performance of the system. It can´t just optimize the performance of individual departments or vertical silos, which can create waste or unevenness elsewhere.

Six Sigma was developed in 1985 by Bill Smith at the Motorola Corporation and was popularized in the late 1990s by former General Electric CEO, Jack Welch [5]. Six Sigma's foundation was in the statistical analysis of data, and this is reflected in its name, which refers to a statistical measure of process performance. Besides Motorola and General Electric, other major corporations

have embraced Six Sigma including AlliedSignal, Lockheed-Martin, Polaroid, and Texas Instruments [3]. The reported advantages to implementing Six Sigma include increased market share and higher profit margins [7]. While Six Sigma originated within manufacturing in the electronics industry, it has since been adopted across many other industries and has spread into the service sector.

The proposal suggested to improve their Service management value streams successfully of the Company is to apply Lean concepts to the Service Department. The primary emphasis is placed on learning to see and then eliminate waste from IT processes, with iterative, agile development cycles that deliver the highest, measurable value to customers as rapidly as possible. This analysis lends to suggest an iterative, agile style of process improvement. This process begins with Discover, moves through Plan, Implement, and Deploy, and on to Manage and Optimize, which brings feedback to the next improvement cycle. To implement this method effectively, the author will lend on Lean Six Sigma, to get the best of both methods. (Fig. 1.2)

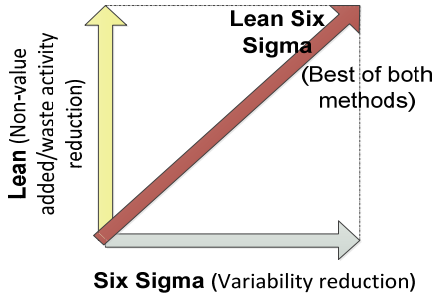

Fig. 1.2. Lean Six Sigma approach.

Six Sigma refers to the philosophy, tools, and methods used to seek, find, and eliminate the causes of defects or mistakes in business processes by focusing on the outputs that are important to the customers [6]. Six Sigma represents a highly disciplined and statistically based approach to quality [3]. Also methodically analyzes underlying data and identifies the root causes of problems as opposed to using subjective opinions. Since every step in a process represents an opportunity for a defect to occur, Six Sigma seeks to reduce the variation in these steps, which results in the occurrence of fewer defects and the production of higher quality goods and services. By controlling this variation, Six Sigma prevents defects from occurring rather than simply detecting and correcting them.

Both methodologies, Lean and Six Sigma, focus on business processes and process metrics, and strive to increase customer satisfaction by providing quality and on-time products and services. Lean takes a more holistic or systemic view (where supply chains compete, not companies). Over the last 10-15 years, an increased need for accelerating the rate of improvement for existing processes, products, and services has led to a combination of the two approaches. As shown in Figure 1.3, Lean Six Sigma combines the speed and efficiency of Lean with the effectiveness and problem solving techniques of Six Sigma to deliver a much faster transformation of the business.

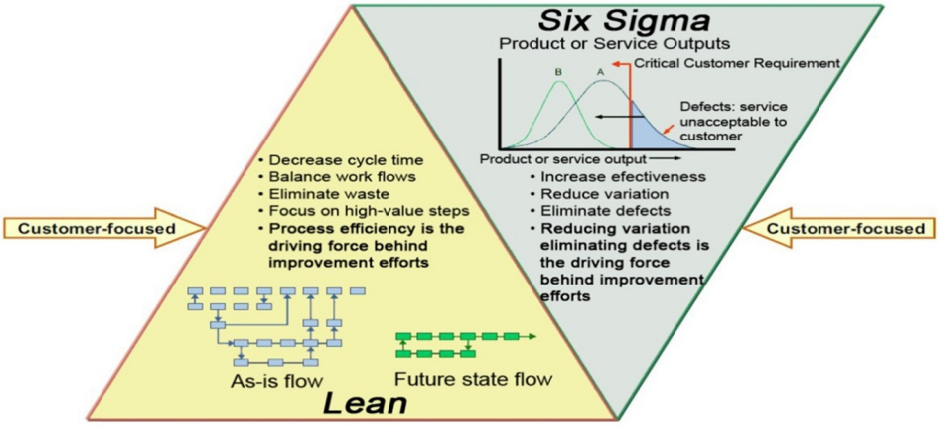

Fig. 1.3. Lean Six Sigma [5]

1.2.1 Six Sigma as a Metric. Principles and Implementation

The Greek symbol σ (sigma) is a statistical term denoting “standard deviation”. Standard deviation denotes how far away the data points are from the mean, it is simply a scaling variable that adjusts how broad will be the curve bell-shaped normal distribution, with a probability density function. The standard normal distribution is “the normal distribution with a mean of zero and a variance of one”.

The phrase *six sigma* refers to several things: one, six sigma is a performance level for a six sigma process, 6 standard deviations; each may be fitted between the mean and the upper and lower specification limits. Allowing for machine wear & tear and operator fatigue, this performance level equates to 3.45 *dpmo* (defects per million opportunities) for a process with a single-sided specification (or 6.9 *dpmo* for a process with a double-sided specification) [6].

Additionally, Six Sigma also is a disciplined and data-driven approach to insuring that repetitive work processes function in the best possible manner. The primary goal of Six Sigma is to minimize defect levels in the outcomes of work processes, a defect being anything that causes customer dissatisfaction. Maximizing customer satisfaction leads to improved bottom-line performance and globally competitive positions.

Figure 1.4 demonstrates how Six Sigma measures quality. If it is achieved 68% of aims, then we are at the 1 Sigma level. If it is achieved 99.9997% of aims, then we are at the 6σ level which equates to 3.4 DPMO. From this point of view, Sigma level is to show how well the product is performing. It seems this level can never be achieved. However, the Sigma level is not the purpose of this work, the real purpose is to improve quality continually. The higher Sigma level is reached, the higher quality is get.

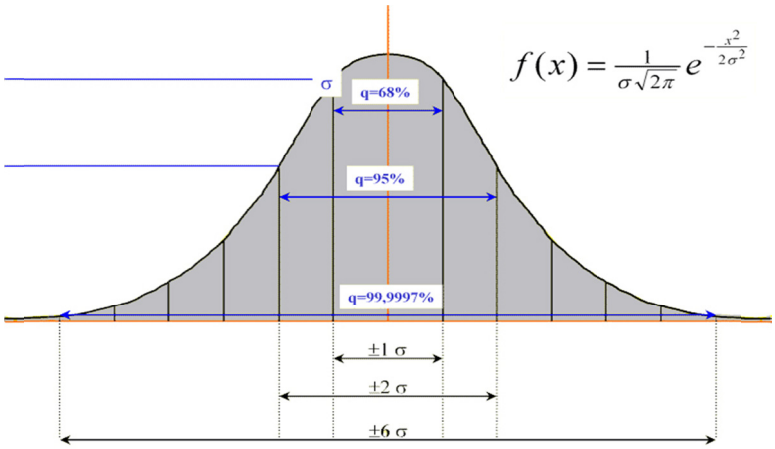

Fig. 1.4. Quality measured in Six Sigma terms

Since Six Sigma is all about enhancing customer satisfaction, it should make sense that it would begin with an exercise to identify who the customers are. Having identified who the customers are, the next step is to find out what is important to the customer, called customer critical-to-quality (CTQ), in Six Sigma jargon. This is a critical step to success with Six Sigma because the supplier perspectives on what is important to customers can often vary substantially from customers' own perspectives. Furthermore, the CTQs expressed by the customer are sometimes fuzzy, not amenable to Six Sigma implementation. In such case, the fuzzy CTQs must be translated into actionable items suitable for Six Sigma implementation.. The approach therefore is to implement Six Sigma on the outcomes of work processes identified in QFD one at a time.

With a specific work process selected for Six Sigma implementation, is it is now the appropriate time to prepare the Project Charter. The project charter is a short document, a page or less, that outlines what problem or problems the customers are having giving rise to dissatisfaction. It lists the outcomes requiring improvement, states project goal, identifies the project sponsor and the Six Sigma team who will work on the project, and provides the start and end dates for completion. Hence, the Project Charter will be the objective to define the CTQ metrics to be studied.

1.2.2 Leverage on Six Sigma using Lean.

According to [6], the principle of Lean Six Sigma is that activities that cause the customer's critical-to-quality issues and create the longest time delays in any process offer the greatest opportunity for improvement in cost, quality, capital, and lead time. The Table 1.1 shows the fundamental differences between the production methodologies Six Sigma and Lean.

Table 1.1. Main differences between Six Sigma and Lean methodologies

Issues/problems/objectives	Six Sigma	Lean
Attacks waste due to waiting, over-production, motion, over-processing, etc.	no	yes
Focuses on customer value stream	no	yes
Focuses on creating a visual workplace	no	yes
Attacks work-in-process inventory	no	yes
Focuses on good house keeping	no	yes
Creates standard work sheets	no	yes
Process control planning and monitoring	yes	no
Employs a structured, rigorous and well planned problem solving methodology	yes	no
Focuses on reducing variation and achieve uniform process outputs	yes	no
Focuses heavily on the application of statistical tools and techniques	yes	no

Six Sigma does not directly address process speed and so the lack of improvement in lead-time in companies applying Six Sigma methods alone is understandable [6]. In a similar manner, those companies engaged in Lean methodology alone show limited improvements across the organization due to the absence of Six Sigma cultural infrastructure. According to Martin [3], Six Sigma projects take months to finish, and they produce elite black belts who are disconnected from the shop floor, while, lean boost productivity but does not provide any tool to fix unseen quality issue. According to [6], lean brings action and intuition to the table, quickly attacking low hanging fruit with kaizen events, while Six Sigma uses statistical tools to uncover root causes and provide metrics as mile markers.

According to [23], a pure Six Sigma approach lacks three desirable Lean characteristics:
1. No direct focus on improving the speed of a process.
2. No direct attention to reductions in the amount of inventory investment.
3. No quick financial gains due to the time required to learn and apply its methods and tools for data collection and analysis.

For the same author [7], the shortcomings of a pure Lean improvement effort are:
1. Processes are not brought under statistical control.
2. There is no focus on evaluating variations in measurement systems used for decisions.
3. No process improvement practices link quality and advanced mathematical tools to diagnose process problems that remain once the obvious waste has been removed.
When run separately, such programs will naturally collide with each other [24]. In contrast, a combination of Lean and Six Sigma has a positive impact on employee morale, inspiring change in the workplace culture because teams see the results of their efforts put to work almost immediately. According to George

[6], Lean Six Sigma directly attacks the manufacturing overhead and quality costs more effectively than any previous improvement methodology because it comprehends both quality and speed. Thus an obvious solution is to develop an integrated approach that will produce greater solutions in search of business and operational excellence, hence Lean Six Sigma.

1.2.3 Six Sigma as Methodology

Six Sigma approach is not just counting defects in a process or product, but it is a methodology to improve processes. Summing up so far, the Six Sigma methodology focuses on [3]:

- Managing the customer requirements.
- Aligning the processes to achieve those requirements.
- Analyzing the data to minimize the variations in those processes.
- Rapid and sustainable improvement to those processes.

When it looks at Six Sigma as a methodology, there are many models available for process improvement like DMADV, DMAIC, Breakthrough strategy, Roadmap, New Six Sigma, Eckes method, Six Sigma Roadmap, IDOV, and DMEDI [25]. The most widely used models are DMAIC and DMADV. The DMAIC model is used when a process or product is in existence but is not meeting the customer requirements. And the DMADV model is used when a process or product is not in existence or is needed to be developed [25] (Additional information for DMADV in Annex 6).

1.2.4 The DMAIC Model

Motorola recognized [6] that there was a pattern to improvement (and use of data and process tools) that could naturally be divided into the five phases of problem solving, usually referred by the acronym DMAIC, which stands for Define-Measure-Analyze-Improve-Control. DMAIC forms the five major phases of any Six Sigma project. This methodology centers on achieving the Critical To Quality (CTQ) characteristic, because it is used when the process does is in existence but is not meeting the customer requirements.

In this case, are shown the phases of DMAIC model, applied to the incident management of the Rboard Company, as follows [6, 26, 24]:

Phase One: Define
Step1 is to **formulate the Problem Statement** articulating what is giving rise to customer dissatisfaction (e.g., 30% of incidences are no solved in a week).

Step 2, it defines the outcome of this work process (e.g., **Solving Time, Minutes from Target)**.

Step 3, it states the project goal (e.g., **Reduce solving time in 30%**). The desired improvement is speculative at this point since it does not know the extent of natural variability present in the process. Nonetheless, the benefits of

defect reduction will be likely being substantial. An estimate of the financial benefits if the targeted benefits are realized should be included.

Phase Two: Measure

Step 4 it **draws a Process Map** showing all the steps in the process including the linkages between steps. The process map will include all the steps, from taking the incidence to its solution.

The *Karma* concept states the outcome of this process, Solving Time, is impacted by causes. It does not tell us what the causes are. We wish to determine what the causes are with Six Sigma so it may work on them to improve the outcome performance. Customer dissatisfaction has emerged as an issue because there is excessive variability in this outcome, that is, the average is not where it should be or could be and the standard deviation is too large. Some of the observed variability in the outcome will be due to common causes which it cannot do anything about within the scope of the problem being scrutinized, but a lot of the variability may be due to causes that it can do something about (assignable causes). Every one of the steps on the Process Map is a potential special cause, i.e., a possible contributor to the variability in the outcome and therefore defects. In a future step, it shall determine which of these potential causes are in fact responsible for introducing variability in the outcome.

Step 5 is to **Validate Measurement Systems**. The central idea here is that the variability in the outcome must come from causes (any one or more of the steps on the process map) and not from errors in the measurement systems. Take as an example, a Voting Process involving voters coming into a polling booth for voting in an election. Here, voters fill out ballot papers, which are processed by a vote-counting machine, and the interpreted results are generated. Clearly, we would want the variability in the outcome (Interpreted Results) to come from causes (Voter Intent) and not from errors in measurement systems (confusing ballot paper design, error-prone vote counting machines). In fact, such errors must be a very small fraction of the margin of victory between the top two candidates or else the election results would be suspect. It is extremely important to validate measurement systems before proceeding to the next step in the Six Sigma implementation strategy.

Step 6 is to **Collect Data on the Outcome(s)** [response variable(s)] for the purpose of determining the starting defect levels.

Step 7 is to scrutinize the data collected and **establish the Current Defect Levels**. It is important to establish the baseline (current performance) so improvement from Six Sigma can be properly catalogued.

Phase Three: Analyze

Step 8 Properly Designed Procedures are employed to collect data on the potential causes and the response variable(s). As previously stated, every one of the steps on the process map is a potential cause. Actual VSM diagram of Incident Management process in the Service Department is used as tool.

Step 9 involves analyzing the data collected for **identifying the Causes** (called major impact factors or vital few causes) that are responsible for introducing variability in the outcome. The cause-effect diagram can be used for prioritization of potential improvements.

Phase Four: Improve
Step 10 the **Major Impact Factors** are determined as either set at the appropriate optimal values or are eliminated. When this is done, the average of the response variable moves in a favorable direction and the standard deviation decreases and all the benefits of Six Sigma accrue.

The valuable sources are customer complaints, competitor analysis, employee suggestions, etc. In general, only poor performance processes or characteristics need improvement. Otherwise, the whole product shall be improved. Future VSM diagram is used as tool in the improvement of Incident Management process.

Phase Five: Control
Step 11 It is related to provide the maintenance of the improved process so that the improved Six Sigma process can run for a long time. There are also two activities in control phase. After improvement phase has been carried out, the planned improvements shall be verified. Improper or incorrect improvements will be discovered and corrected in the next improvement project. Track Chart is highly recommended to verify the long-term effects of improvements.

Another important activity in this phase is to formalize the results. The results which only match a single process or product will be reorganized and reanalyzed to match the whole company. Both successful and failed cases shall be formalized, reported and stored. The companies should gain experience from those cases for further improvements. Based on that, a guideline shall be established. And that will be very helpful for the future Six Sigma projects. Every company shall create their own Six Sigma project guideline [14, 23, 27]

1.2.5 Six Sigma as a Management System

Through experience, Motorola has found that using Six Sigma as a metric and as a methodology are not enough to drive the breakthrough improvements in an organization.

Motorola ensures that Six Sigma metrics and methodology are adopted to improve opportunities which are directly linked to the business strategy. Now Six Sigma is also applied as a management system for executing the business strategy. Six Sigma approach provides a top-down solution to help the organization. It put the improvement efforts according to the strategy. It prepares the teams to work on the highly important projects. It drives clarity around the business strategy [31]. For such reasons, the approach of Six Sigma as Methodology is an extension to the Control phase, as a commitment of Management team to its long term application.

1.2.6 Techniques and tools in Six Sigma

Since the Six Sigma approach is invented, many old quality tools are adopted in Six Sigma process improvement project. At the same time, some new specific tools and techniques are introduced.

There is no a specific tool or technique for one specific phase in Six Sigma. Any tool that is helpful for the process improvement can be applied in Six Sigma project. There are tools most widely used in all kinds of quality improvement. They are Cause-effect Diagram, Pareto Chart, Flow Chart, Histogram, Check Sheet, Control Chart, and Scatter Plot. The other special tools are gathered from successful Six Sigma cases which include Brainstorming, Affinity Diagramming, SIPOC Diagram, MSA, VOC Method and so on. Tools are tools. Using the proper one in the right place is the key factor which influences success. How to control such great power demands the understanding and familiarity of tools and techniques. That is why is needed the help from specialists. The functionality of these tools is described in Annex 7.

After all, Six Sigma's definition has reached three levels: as a metric, as a methodology, and as a management system. As a metric, it aims to reducing defects. The highest level "6σ" equates to 3.4 defects per million opportunities. Then, as a methodology, it is used and focused on improving process. In this case, DMAIC and DMADV models are the most common used. After that, as a management system, it can be performed, combining the metric and methodologies for executing the business strategy, and aims to continuous improving services quality, for a long period of time. This last phase will depend exclusively on Management's implementation in the Company.

CHAPTER 2. DEFINING SERVICE MANAGEMENT OBJECTIVES

So far has been conducted a literature review about Lean Six Sigma, in order to be able to identify critical success factors for incident management in Service Departments.

Moreover, for this company has been undertaken a review into the characteristics displayed by the Incident Management and its approaches is used to observe the problems while working to restore service when unplanned outages occur and then identify the opportunities to be solved. Once the all picture of the activities is obtained from the Service Department environment, the Project Charter is defined in this chapter.

Then, the idea is to quantify how much of the process will be improved, using measurable objectives. To do this, are established the problem statement and problem objectives:

- Problem statement: Management of 620 incidents (mean), in 22 labor days at month. Incidences are piled up in no labor days in customers' offices. Rboard works 8 hours daily, individual overtime if it is necessary. About 25% of incidences unsolved in 24 hours or less.

- Problem objective: Management of 620 incidents (mean), in 30 labor days at month. Incidences are stored in no labor days in Rboard's automatized Customer Service System. Remains Rboard working 8 hours daily but individual overtime rarely necessary. Reduction to 0% of unsolved incidences in 24 hours.

Once determined the current state of the Service Management, then two characteristics Critical to Quality (CTQ) has been defined to measure the service quality:

- The *Loss Incidence* metric is to count the total number of incidences that were lost, that means, completely unattended or attended only after 24 hours.

- The *Customer Complaint* metric is to count the total number of complaints from customer.

Table 2.1. Service Management metrics for Incidence Management quality

Process Metrics	Description	Data to measure
Loss incidence	Measure how many incidences are lost among all the others	Potential customer info, incidence type, loss or not, time of waiting.
Customer complaints	Measure the number of complaints received among all the possible complaints	Customer info, complaints problem, solved or not, time of waiting

With the CTQ characteristics, the next steps centre on achieving these CTQ's, furthermore it helps to decide which process should be improved. To take a clear view of the scopes, objectives and team involved, is presented the Project Charter.

Table 2.2. Project Charter

Project Name	Improving Customer Service System (CSS)	Project number:	
Sponsoring Organization	Rboard – Service Department		
Project Sponsor	Name: Office:	Phone: Email:	
Project Leader	Name: Office:	Phone: Email:	
Project complexity:	High	Resources:	Attached in appendix
Project Start:	October 2013	Project End:	January 2014
Teams	Name: A., Juan	Email:	Title/Role: CEO Spain
	Name: B., María	Email:	Title/Role: Programmer
	Name: C., Juan	Email:	Title/Role: Programmer
	Name: D., María	Email:	Title/Role: Programmer
	Name: E., Juan	Email:	Title/Role: IT Engineer
	Name: F., María	Email:	Title/Role: IT Engineer
Methodology:	DMAIC	Process type:	Customer Service
Milestone			
Define:	Start 10/2013		End 11/ 2013
Measure:	Start 11/2013		End 12/2013
Analyze:	Start 12/2013		End 15 01 2014
Improve:	Start 15 01 2014		End 31 01 2014
Control	Start N/A		Start N/A
Problem Mission Statement:	To increase customer satisfaction to the Help Desk. The company decides to reduce rate of unsolved incidences and customer complaints.		
Problem Statement:	Nowadays, the customer complaints and incidences unsolved are increasing. Help desk complains that there is no standard procedure to manage incidences. The quality of service is declining.		
Project Objective:	– To reduce the Solving Time in 30%, attending successfully incidences, taking into account more incidences in near future. – Reduce Customer complaints from 15% to 0%.		

As a final result, this Project Charter defines the characteristics to be improved.

To take into account the measurable objectives in this project, in first place are necessary to gather preliminary information about incident managers, technical and managerial professionals with whom they work. Second, it is necessary to

design, develop, and validate interviews and questionnaires to measure characteristics displayed and approaches used by incident managers to solve problems when unplanned outages occur. Tools used are: VSM, Lean VSM, Cause effect charts, Cheek sheet, Brainstorming and Voice of the Customer (VOC).

In cases like this, service improvement projects have to deal with customers. It must be pointed out that to capture the Voice of the Customer (VOC) is a difficult task to be accomplished. It would rather to use the direct contact methods like interviews at the point of provision, instead of the less direct method of collecting feedback comments on the daily breakdowns submitted by the managers.

To compensate for this limited amount of information, it has been based on the weekly technical meetings and workers observations directly on the Help Desk in order to identify the measurable objectives, also called Critical to Quality characteristics (CTQ's), which should be addressed by the outputs of the process.

Hence, the next chapter would reveal information about the characteristics displayed by incident managers while working to restore service when an incident occurs. Trying to follow the steps indicated in the DMAIC methodology, will be described the measuring in Solving Time for incidences and then analyze the causes that produce variability on it. After that, reviewing the incident management procedures, several changes will be proposed to make important improvements.

CHAPTER 3. DESCRIPTION OF THE SERVICE DEPARTMENT

3.1 Company Background

Rboard - Information Systems is an international leader in the development and provision of software solutions and specialized services for the computerization of firms of the packaging, corrugated board, carton, paper conversion and flexography sectors.

This company has specialized in ERP software in management solutions, which at present counts over 160 important installations worldwide at leading firms in the packaging and paper conversion sector. It was established in 1981 and currently employs around 150 people in Italy and Spain, providing a host of services such as Consultancy, Assistance and Training by a Centre of Competence comprising many multidisciplinary experts.

The Rboard business concept is presented here:
“Rboard’s mission is to enhance and develop global leadership in ERP systems and services for the manufacturing cardboard sectors.
The aim is to be the best in the industry at:
– providing customer value,
– developing capabilities in employees
– creating shareholder value.”

Rboard’s attitude and commitment to quality is communicated through its Quality Policy: “Aim for total quality in everything we do: market only systems and services that will ensure customer satisfaction by:
– Operating reliable and capable processes,
– Maintaining a program of continuous improvement.”

Rboard’s largest individual customer is Smurfit Kappa. Other important customers are in different segments worldwide, for example, recycling paper industries, paper mills and flexography and cardboard sectors.

3.1.1 Service Department

This thesis is focused on the subsidiary at Rboard’s Customer Service System (CSS), in a Service Department which comprises 12 engineers and 10 programmers in Italy and 2 engineers and 2 programmers in Spain (Fig. 3.1). This department is provided as a part of its Customer Relationship Management. Its function is to supervise the installation, customization, evaluation, training and solving incidences using the ERP system; also it is divided into two sections: Help Desk and Programming.

All the customers address their everyday problems in a mean of 620 monthly incidences to the CSS. About 75% are solved in 24 hours or less but the remaining 25% is over 72 hours to resolve successfully.

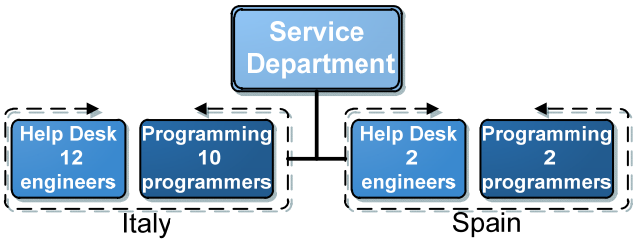

Fig. 3.1. Organization chart of Service Department in Rboard.

3.2 Case Study: Present Stages

This section starts with an overview of the technical architecture of Incident Management in the Service Department, and proceeds to the discussion of the results of the current state analysis based on interviews and questionnaires conducted in the case company. It tends to leverage in the Define phase

This procedure is similar to the Define first-phase, used in DMAIC methodology, to know about the inner processes in the day-to-day activities in the Service Department. The purpose of observing the incident's lifecycle is to set the goals and improve in the effectiveness of the service. To achieve this, the duration of the observed phases in Rboard's Service Department is measured, creating an *As-Is* process, describing the complete Service Management in a relative logical way:

- Occurrence: the incidence of unplanned disruption to an agreed service;
- Notification: the process which occurs sometimes after the occurrence of an event;
- Diagnostics: identification of the characteristics of the incident;
- Review: the process of reviewing the failed items to their last recoverable state,
- Testing: the process of checking the expected service back to the client;
- Repair: a process of review actual conditions;
- Closure: the final step in the incident lifecycle, during which the client and an incident solver check that a service is fully available;

and then, in the next chapter, in a measure phase, using the data found with surveys, will be determined:

- the longest phases and try to shorten them if we find them unjustifiably long;
- look for changes in duration, and identify and stop any unjustifiable increase in their duration.

At present time, all of these steps are followed in a no proper way by Rboard. The next four identified lifecycle stages have not well-defined boundaries and activities, so the main intention is to suggest the clear procedure to offer a solid

structure in the process and also will allow to measure times in each stage.

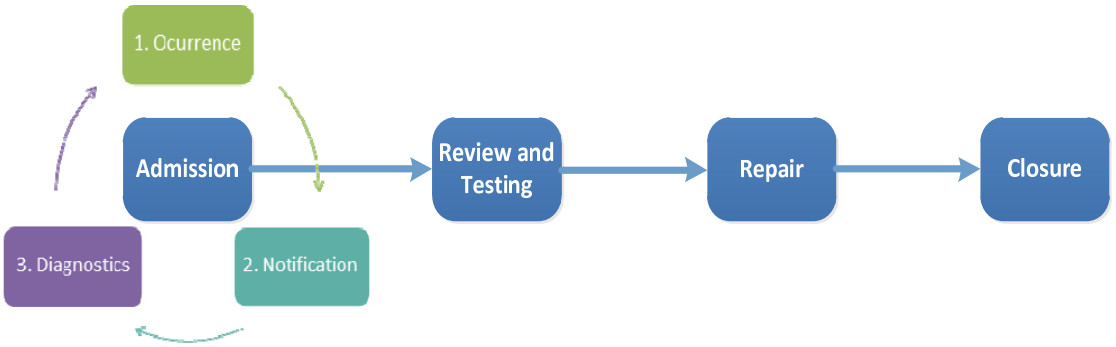

Fig. 3.2. Actual Incident handling workflow in the Service Department.

The current technical architecture of Incident Handling is defined in the following elements: a) Customer; b) Handler (Solver) in Spain; c) Handler in Italy, both of them are a suite for handling IT service related processes and d) Programming Department. The complete swim lane can be observed in Fig. 3.7.

The *Customer* is not a part of the case company. It includes all the IT departments of the companies that Rboard assist with its ERP. The *Solvers* are the Service Department, which are responsible for monitoring and resolving Service tickets, which comprise of incidences and service requests, and providing functional knowledge and training regarding the existing IT applications in the ERP scope of the Customer Service System. The *Customers* of the unit are Key Users of the ERP applications who are in contact with application End Users to help them to solve applications related issues/problems. Thus, the majority of incidences tickets are submitted to ERP by applications' Key Users.

3.2.1 Admissions

1) Occurrence

This is on Customer level. Whenever an application user has a question, a query or a problem related to the application in ERP scope, he/she contacts a Key User of that application who represents Level-1 support in the Customer. Annex 3, Fig 3.1, shows in the RPM software the set of incidences received.

2) Notification

In case the Key User is unable to resolve the issue, he/she notifies an Incidence to the ERP Level support in the Service Department. It is mandatory that the Handler open an Incidence ticket for further fulfillment. In some cases, questions, queries or problems related to an application are reported to this Help Desk, who also acts opening a ticket, but usually is solved without any escalation for resolution. If the problem does not exist previously in the

Database, then setting up a new task in the system is mandatory. If it already exists, then it redirects to the next step.

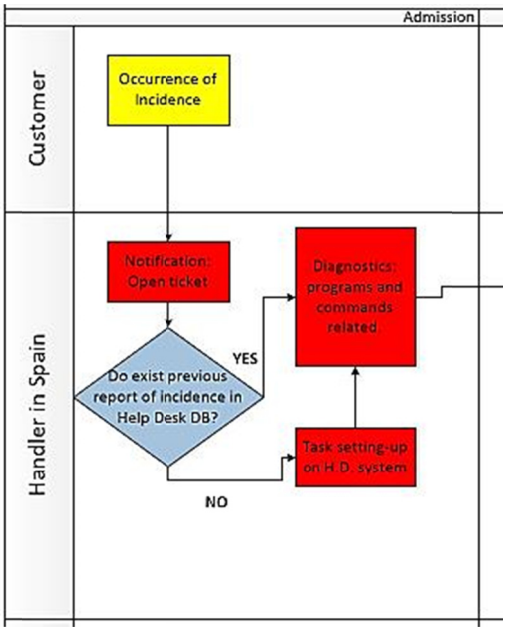

Fig. 3.3. Part of the swim lane showing the Admission stage.

3) Diagnostics

The Help Desk solver checks the commands and programs related to the incidence reported and add this information to the open ticket.

3.2.2 Review and Testing

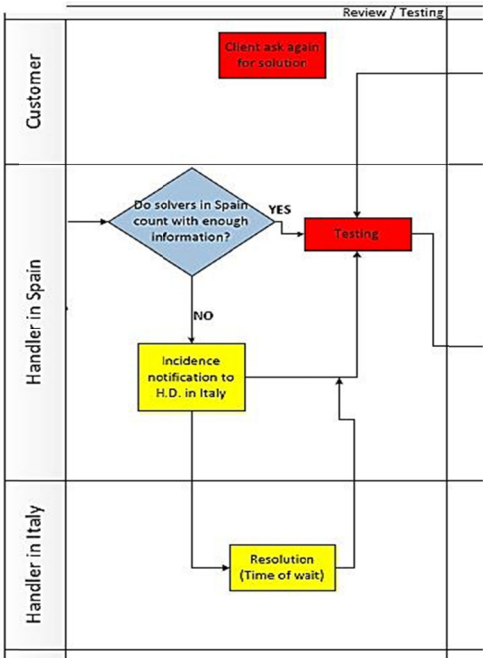

Fig. 3.4. Part of the swim lane showing the Review and Testing stage.

Once the Solver in Help Desk assigns information and categorizes the incidence, it is attended by an IT technician. Remember this Service Department is comprised by only 2 engineers, so it is possible that the same person that attends the case in the first stage try to solve the incidence or pass it on to an another technician. In Annex3 Fig 3.2, shows the classification of each incidence received.

In any case, if the Solver has enough information, he/she will try to make tests using the existing Knowledge article as the solution to the issue. If the ticket cannot be resolved by this support specialist, it will be escalated to the Handlers in Italy, offering support for possible resolution. This step is generally avoided, because add a lot of waste of time that is charged to the Customer, who asks for the solution to the Service Department in Spain, but they have to wash their hands, hiding as much as possible that the incidence is being attending by the Italian team.

At least, when solution from this team is proposed, then it is escalated again to the team in Spain, which tests and then it is saved, among other, in a Database. The Customer makes a Self-Search, in which the Key User of it can search for a solution to the problem from the existing knowledge base.

3.2.3 Repair

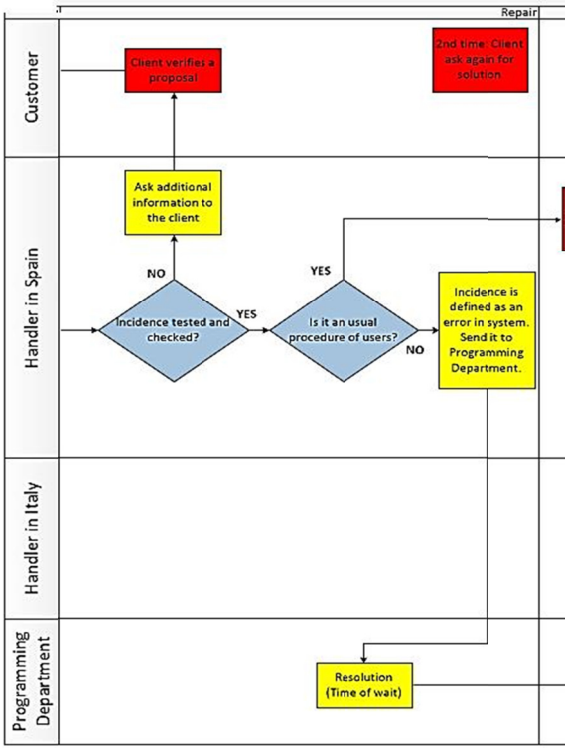

Fig. 3.5. Part of the swim lane showing the Repair stage.

The solution proposed is tested but still do not checked, then the Solver asks again to the Customer for more relevant information, which incurs in waste of time. The Customer (Key User) does not have time to attend properly so many

ask from the Service Department, so there is a delay in solution time. In Fig. 3.3, Annex 3, there is an incidence, historical and repairs.

If the Solver tests and checks properly the solution, even entering remotely to the Customer's system, then appears an additional issue: if it is a usual procedure of users, a day-to-day activity, then it goes to a next stage. If instead of it, the incidence is not usual, then it is considered as an error of the system and it needs to be fixed completely using depth programming skills. To do that, it is scaled to the Programming Department. Obviously, it consumes more time and money that the Customer has to pay, so its Key User asks again for the solution. As can be seen, the Repair stage does not offer a final solution for the incidence at all.

3.2.4 Closure

The incidence follows two ways to arrives to the final stage. The first one, if it is considered as a repetitive incidence, then training with additional explanations of procedures is introduced to the Key User, and the Customer must pay for it. The other way to close the Incidence comes from the Programming Department, which notify to the Key User directly, leaving a copy of in the Knowledge Base and notifying to the Help Desk team. Sometimes it occurs that this team is not warned properly, so the solution remains in Database as not solved, even the Key User already has the solution. This situation generates confusing, because in one case is the Key User that closes the ticket by itself and sometimes is the Help Desk that closes it.

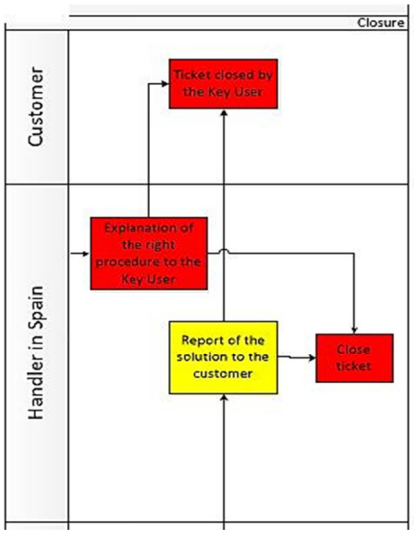

Fig. 3.6. Part of the swim lane showing the Closure stage.

Additionally, it does not offer a clear image from the Service Department to the Customer, because it has to deal with several teams inside one company, affecting the quality in the service offered to the Customer. The next figure shows the whole Swim Lane Diagram of the actual Incident Handling in the Service Department.

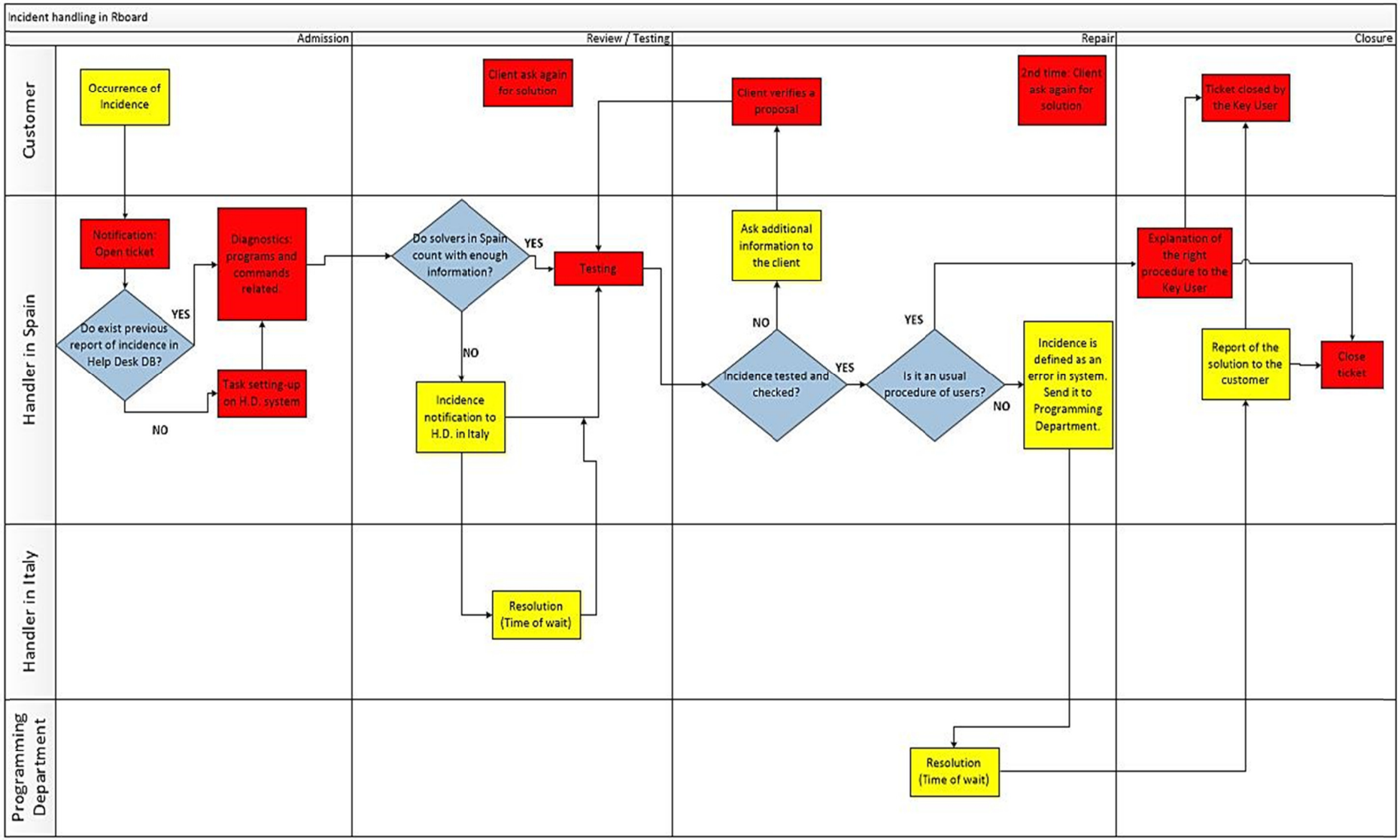

Fig. 3.7. Complete Swim Lane of Incident Handling procedure in Rboard

CHAPTER 4. PROCESS ANALYSIS

The reviews of processes observed can be divided into two basic paradigms; namely quantitative and qualitative [20]. According to this author, these two types of inquiry are sometimes viewed as competing views about the ways in which social reality ought to be studied, and at other times as different ways of conducting social investigations.

In summary, quantitative analysis main concerns are reliability, objectivity, representativeness, generalizability, replication and validity of investigation's findings. Hence, the above inform about the method that was followed in this study, in which both a qualitative and a quantitative dimension were used as an approach. This involved document analysis, and individual interviews and questionnaire surveys

4.1 Procedure followed in the Service Department

The study requires evaluating employees' perceptions on the implemented Customer Service System (CSS) at Rboard, to assess the methodology used to develop, implement and maintain the service quality management.

The Rboard Company approved to obtain information about its main activities, both in Spain as in Italy offices. But the main condition is to identify this Company using a pseudonym. Valuable data was obtained in some cases, but limited in access to the Customer Service System of the ERP that they implement in their Customers. The information led to conclude that its IT Service Management has an incident management team that would not be large enough to deal the broad spectrum of actual and future unplanned outages.

It was possible to arrange a meeting with three of the senior corporate executives at Rboard in Spain and Italy, who, in turn, met with the corporation legal representatives to obtain approval to extend informal invitations to a subset of its employees to participate in the surveys. Complete anonymity was assured to both the corporation whose employees participated in the meetings, queries and surveys and to each individual participant of the Service Department.

The selected area within this Company was granted and accessed through a formal introduction by the office of Italian CEO. This CEO mandated the Service Department to coordinate the review of its procedures, and be the point of contact between the whole organization and myself. This process was then progressed by a physical visit and formal introduction to the Service Departments, In Italy and Spain, which in turn identified all the three areas where the CSS had been implemented.

Fortunately, in both these areas was proved to be an important task as

everybody involved in the intervention was concerned about knowing the effects of the program in Lean in Service Management (LSM) on the organization, and they were willing to assist in the surveys. The CEO also viewed this review as a tool that could be used to make a decision on whether the LSM program should rolled out to other areas, as planned in their medium and long-term strategic objectives.

The final aim of the measure phase is to baseline process capability and potential through the development of clear and meaningful measurement systems. The first obstacle to overcome is how it is going to measure the current process performance since there are neither established performance indicators nor automatized data collection plans in place.

Rboard has not been making use of a reliable method of recording either the incidences working-on times or the precise reasons of clients complains , which would allow to understand the statistical "conduct" of the process.

4.2 Data Collection Method

There were two phases. Phase one of the study was quantitative in nature, and these involved questionnaire surveys, whereas phase two was qualitative and involved individual interviews of employees.

4.2.1 Non-probabilistic sampling

This study used non-random sampling, also known as a purposive or judgmental sampling method, to sample the areas and the individual interview participants [20]. In total, two different regional areas, and the Service Department which is based at the head office, were chosen as the geographical areas of the study. Choosing these areas was convenience because it is concerned with persons involved in implementing the Customer Service System. This means that the employees in this department have first-hand information on the method that was used to develop and implement the quality in service management system.

4.2.2 Distribution of questionnaires and individual interviews.

The following steps were followed in conducting individual interviews and in the distribution of the questionnaires:

- recruitment of participants;
- interview and questionnaire distribution setting;
- interview and questionnaire guide.

In the two regional areas, there is Help Desk and Programming departments, which comprise the Service Department (see Fig. 3.1). In Spain, 2 individual interviews were conducted in each of the two departments (4 in total), followed

by 5 individual interviews in Italy, 1 CEO, 2 Help Desk engineers and 2 Programmers. In total, 11 interviews undertaken.
In each, Help Desk and Programming, was interviewed the team leader, purposively selected for the interviews due to the fact that team leaders are the core of development and implementation of the quality in customer management system.

In this study, participants were drawn from those staff members who were regularly exposed to the customer's attention and had something to say about it. It should be noted that questionnaire surveys were conducted also in the two regional areas. The number of questionnaires was distributed in this way: Spain, 5 questionnaires (4 same previous members and 1 CEO); Italy, 4 in Help Desk and 2 in Programming staff, none of them participated in the interview. The distribution is shown in the next table.

Table 4.1. Distribution of individuals for interviews

Area	Date	Function	Total
Spain	October 2013 to Nov. 2013	Help Desk	2
Spain	October 2013 to Nov. 2013	Programming	2
Italy	Nov. 2013 to Dec. 2013	Help Desk	2
Italy	Nov. 2013 to Dec. 2013	Programming	2
Italy	Nov. 2013 to Dec. 2013	CEO	1

Table 4.2. Distribution of individuals for questionnaires

Area	Date	Function	Total
Spain	October 2013 to Nov. 2013	Help Desk	2
Spain	October 2013 to Nov. 2013	Programming	2
Spain	October 2013 to Nov. 2013	CEO	1
Italy	Nov. 2013 to Dec. 2013	Help Desk	4
Italy	Nov. 2013 to Dec. 2013	Programming	2

4.2.3 The interview guide

The interviews guide, administered in English, was developed using the 6 DMAIC phases of developing and implementing a Six Sigma. The interview guide's purpose was to serve as a guideline to chart the course of the interview from the beginning to the end. This meant that the interview guide was like an agenda. The guide was prepared in advance to avoid a situation which it was possible to forget essential points as well as to keep the focus of the group on subjects relevant to the objectives. The model of interview is in Appendix 1

In the preparation of a clear interview guide, the aim was to evaluate the interviewee's perceptions of Lean concepts and quality in service management, on whether it was perceived to have improved the operational efficiency of the department. An effort was made to ensure consistency in the use of the guide in all individuals interviews held during the study. There no was time to carry on piloted interviews previous the actuals.

4.2.4 The Questionnaire

Drafting questions is a crucial aspect of developing any assessment instrument since what you ask for is what you get. With regard to the development of standardized tests, questions should be short and concise, relevant to objectives. The model of questionnaire is in Appendix 2.

As with the interview guide, the same method used for developing an interview guide was used. Also the 6 fundamental concepts of developing and implementing Lean Six Sigma were used to develop the questionnaire. The questionnaire, administered in English, elicited responses from staff members to evaluate their perceptions of whether the implemented management service was perceived to have improved the operational efficiency and measures the quantity in loss incidences. In this way, was obtained an indirect view of the way as the customer observes the service offered by Rboard's Service Department and a measure for customer complaints. For additional information about data reliability and validity, see Annex 8.

4.3 Defining Performance Indicators

As previously mentioned, it is necessary to develop metrics either called Performance Indicators, which reflect the performance of the service process. Based on the Critical to Quality (CTQ) features derived from the Voice of Customer (VOC), it concludes that the kind of data necessary to collect are the number of loss incidences and the customer complaints.

The operational definitions of these Performance Indicators are mainly associated with the effectiveness of the process in the eyes of the customer. The customer is an external one, the Key User of the RPM, and he wishes the smooth performance of the whole service. However, a project should also have some indicators of performance that reflect the efficiency of the process from the internal perspective and such one could be the cost of poor service and especially the costs related to unnecessary working time on incidences. So, it is quite clear that is necessary to achieve a balance of measures covering speed, quality and cost.

1) Performance Indicator 1: Incidence Working-on time (minutes): It represents the time elapsed between the incidence is received (open ticket), due to any request of the Key User and the closure of it and return to normal activity.

Detailed definition: Beginning of time: the time when an incident occurs and the RPM fails in any process, forcing the users and Key User to either repair it himself or ask for the technical assistance to the Help Desk.

End of time: the time that the RPM returns under normal operation.

2) Performance Indicator 2: Number of customer complaints (occurrences): The number of occurrences of a contact of Key Users or users of RPM.

Detailed definition: Any time the Key User asks for a non-provided solution, for a solution provided but not-tested, for a solution that does not work well or it is a no final and absolutely resolute solution that is not repeated in near future.

The Performance Indicator 1 belongs to the “continuous” data because it is related to the measuring of a service characteristic, while the Performance Indicator 2 is of “count” data as it results from counting things. It is very important to know the different kinds of data involved in the project as it has implications for the type of tools and techniques that will be used later on analysing phase during the project.

4.4 Data measured

A measurement to the Critical to Quality factors is made. The two first help to understand the Performance Indicator 1; the last one measures the occurrences in customer’s complaints along the last 12 months.

4.4.1 Availability

It represents the percentage of time that each Help Desk section offers the service that it was deployed to provide.

$$\boldsymbol{A = \frac{(M-P)}{M}} \qquad (4.1)$$

A= Availability; M= Minutes per day; P= Planned outage minutes per day
Table 4.3 provides the availability calculated for each section.

Table 4.3 Calculating availability

Item / Section	Minutes per day	Planned outage (minutes per day)	Availability
Incidences Management	390	112	71,28%
Help Desk Italy	390	30	92,31%
Help Desk Spain	390	90	76,92%
Programming	300	60	80,00%

The sections have similar availability, but Help Desk Italy has more capacity to attend incidences, with its high 92% of availability.

4.4.2 Mean Time to Restore Service

It can measure the mean duration from opening until closing the ticket, which means, the restore to normal service or operation. Hence, MTRS is the time taken to restore normal service to an acceptable operating level.

$$\boldsymbol{MTRS} = \frac{\sum_{i=1}^{n}(T_i)}{n} \quad (4.2)$$

Table 4.4 reveals the different values. In this case, the Incidences Management section has a different concept for MTRS, it refers to the mean time of it to receive and dispatch each incidence.

Table 4.4 MTRS in Service Department.

Item / Section	Working-on time (minutes)	Incidences number (n)	n unsolved	n solved	MTRS (minutes)
Incidences Management	390-112= 278	28	0	28	9-10
Help Desk Italy	390-30=360	6	4	2	60
Help Desk Programming	390-90 =300	16	3	13	18-20
	300-60=240	6	0	6	40
	Percentage:	100%	25%	75%	

In despite of Italy team attends few incidences; their solving time is very high. Also, 25% of incidences are unsolved in 24 hours or less.

4.4.3 Customer's complaints classification

This measure is related to Performance Indicator 2. There are classified in three types of measures:

A. Key User or any final user asks for a still non-provided solution. Even if it does not asks, the solution is not provided and Service Department is concerned about this situation and counts as if the Key User is "waiting in silence"
B. Solution provided but not-tested by the Help Desk team.
C. Solution provided and tested but needs near-future adjustments or the problem is still present in the RPM

All of them were extracted from interviews and supervising directly the Incident handler program. The results are represented in the next chart (Fig 4.2), showing the total of each type of complaint by month and its respective tendency line along the year.

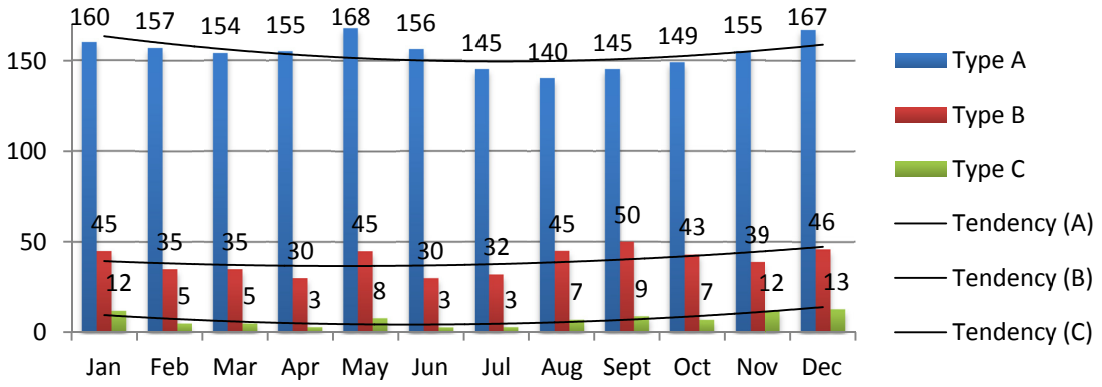

Fig. 4.1. Chart showing types of customer complaints

CHAPTER 5. ANALYSIS OF OPPORTUNITIES

The analysis in general went well; there were however some challenges encountered during the data collection. The first logistical challenge was to get permission to conduct the data gathering from the top management. It took about one month before the permission was granted and then only with restrictive conditions. Also, the complete results were obtained in January 2014, after more than one month of standby.

The results of this study are derived from analysis of some Rboard's document, the data derived through individual interviews and questionnaire surveys and from the study of the Incidences Software that the Company uses (see Annex 3). After the analysis, at the end of this chapter is presented the actual Lean VSM of the Incident Management process in the Service Department.

5.1 Analysis of data from interviews and questionnaires

5.1.1 Standards in procedures

The Customer Service System and hence, the Service Department, does not follow Incidences Management procedure, as ITIL frameworks recommends. This was reviewed extensively in Chapter 4. The team in both regional areas felt that improvement of quality of service, speed of response in service, dependability and reliability of the service provided were main goals that the organization must reaches. Flexibility of the service provided could achieve a reduction of costs in hour/man for the Company.

The number of complaints of the customers is increasing, having in a big impact on the image of the organization. Also, the teams are concerned about a next increment in new clients, which could not be attended properly, if a new procedure to improve the quality in service is not implemented early.

The majority of the respondents, 100% in Spain and 70% in Italy, agreed with the fact that performance objectives, i.e., quality, speed, reliability and dependability of service delivered by the Service Department, including reduction of costs could be improved by the implementation of the a methodology like Lean Six Sigma, but there was a big differential between the two regional areas, that is, might have been brought about by inadequate training in the Italian area which was is less enthusiastic about the benefits of the intervention of improvement projects.

Almost the total of interviewees knew their Quality Police: "*Aim for total quality in everything we do: market only systems and services that will ensure customer satisfaction*" and they accepted that the vision was well communicated through various means including the internet and posters.

The number of incidences not solved properly is the big concern of the Service Department. About 75% are solved in 24 hours or less but the remaining 25% is over 72 hours to resolve successfully. Also they know that near a 20% of the customers have complaints even if the incidence is solved or not and also they feel the time to response effectively is too high.

They all answered that the quality performance and the level of satisfaction of the customer was measured internally, so surveys and benchmarking to customers have not been applied in a formal studies. However, due to non-availability of objective evidence, it could not be verified the costs involved in loss service.

It is said that identifying output variations is a key aspect of Lean Six Sigma because such deviations from quality standards are measured by the percentage of defective products, or in this case, of customer satisfaction, by on-time response percentages and customer survey ratings. Rboard Corporation is committed to reduce time wasting to zero and response all the incidences in less of 24 hours.

5.1.2 Causes and effects

Both CEO's regional departments were involved and committed to the implementation of the improve quality in Service Management. Italian chief knows about the communication problem between regional departments, both Help Desk and Programming, in spite of the frequent annual training in technical issues. All the Italian Help Desk and Programming members were concerned about the management capabilities of Spaniard CEO to carry out improvements, but they are sure about the concern of him to understand and please the customer's requirements in time, quantity and quality.

Besides, both regional CEO's and the Director of Rboard rewards which are process-oriented, where improvements such as an improvement in speed, demonstrated by reduction in cycle time, customer satisfaction with product quality, flexibility and dependability of the goods and services are in place. That means, the rewards are based in performance objectives, linked to process-oriented improvements, which reinforce the belief that continuous improvement will be sustained and this will ultimately develop into the organizational culture.

With this analysis, it is possible to entitle the main causes and define the two metrics in the process of Service Management, which are shown the next Cause-Effects diagrams.

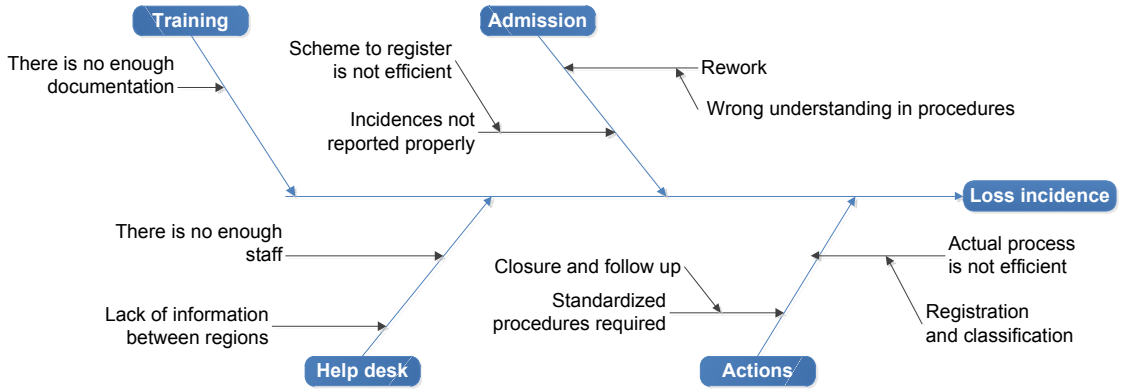

Fig. 5.1. Cause and effect diagram for Loss Incidence Process Metric in the Service Management.

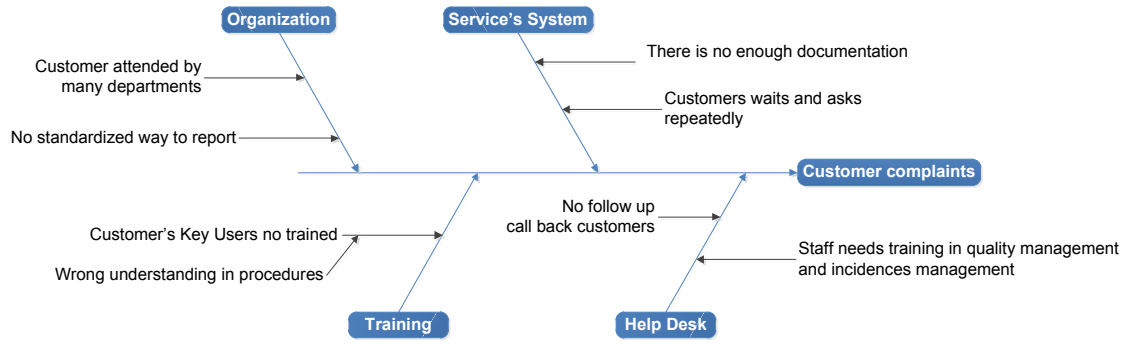

Fig. 5.2. Cause and effect diagram for Customer complaints Process Metric in the Service Management.

5.1.3 Auto-evaluation results

All the Spaniard team, by age or level of knowledge, is willing to apply any change in improvements. The Italian team, with more expertise and age, is more confident about its own procedures are not prepared to deep changes. The Italian chief could think in some change in motivations to be more collaborative with the Spaniard team.

They all Spaniard team also agreed that the implementation of projects for improving quality (as Lean Six Sigma) could help to gear towards the improvement of all the organizational processes. They further indicated that the following quality improvement projects could be implemented to improve departmental processes:

- Suggestion of a new scheme of Incidence Management, led to implementation of a system where incidences were solved in time. Previously the customer store incidences in a better labeled way, to be solved for any technician;
- Standardization of incidence's system in this department;
- The suggested scheme gave members an opportunity to come up with value

adding suggestions. This initiative was well received by Italian teams.

The interviewees knew that their perception of its vision was well communicated and also they thought the strategy and the people were focused towards that vision of improvements. Despite the actual problems, they feel the organisation performance was moving into the right direction.

The team is confident about the performance management system, so they are sure about the customer's level of satisfaction and dissatisfaction. Instead of it, they feel it is necessary more communication with the client after an incident is closed. The team in Spain is not as well motivated as the Italian team. They don't understand and accept their superior performance and the feedback process is not clear at all.

Interviewees accepted that the rewards and discipline measures used to extinguish unacceptable behaviour and encourage exceptional behaviour were working for the organisation. The recommendation is that organization should continue to give recognition of good performance through bonuses. According to one of the interviewees, a collective performance management system is better than an individual performance management system, the reason for this view is an observation that after the migration from an individual to collective systems, there was an improvement of about 100% in the Help Desk area (in Italy).

All the interviewees said that they just did receive few training in Service Management together. Otherwise, the members from the Programming area only received in-house training, given by its supervisor. Department Senior managers (in Italy) should be willing to allocate resources to improve quality in implementation of incidences management, particularly to make investments in more long-term training, taking advantage of the high level of commitment of all the staff members.

5.2 Actual VSM diagram of Incident Management process in Service Department of Rboard.

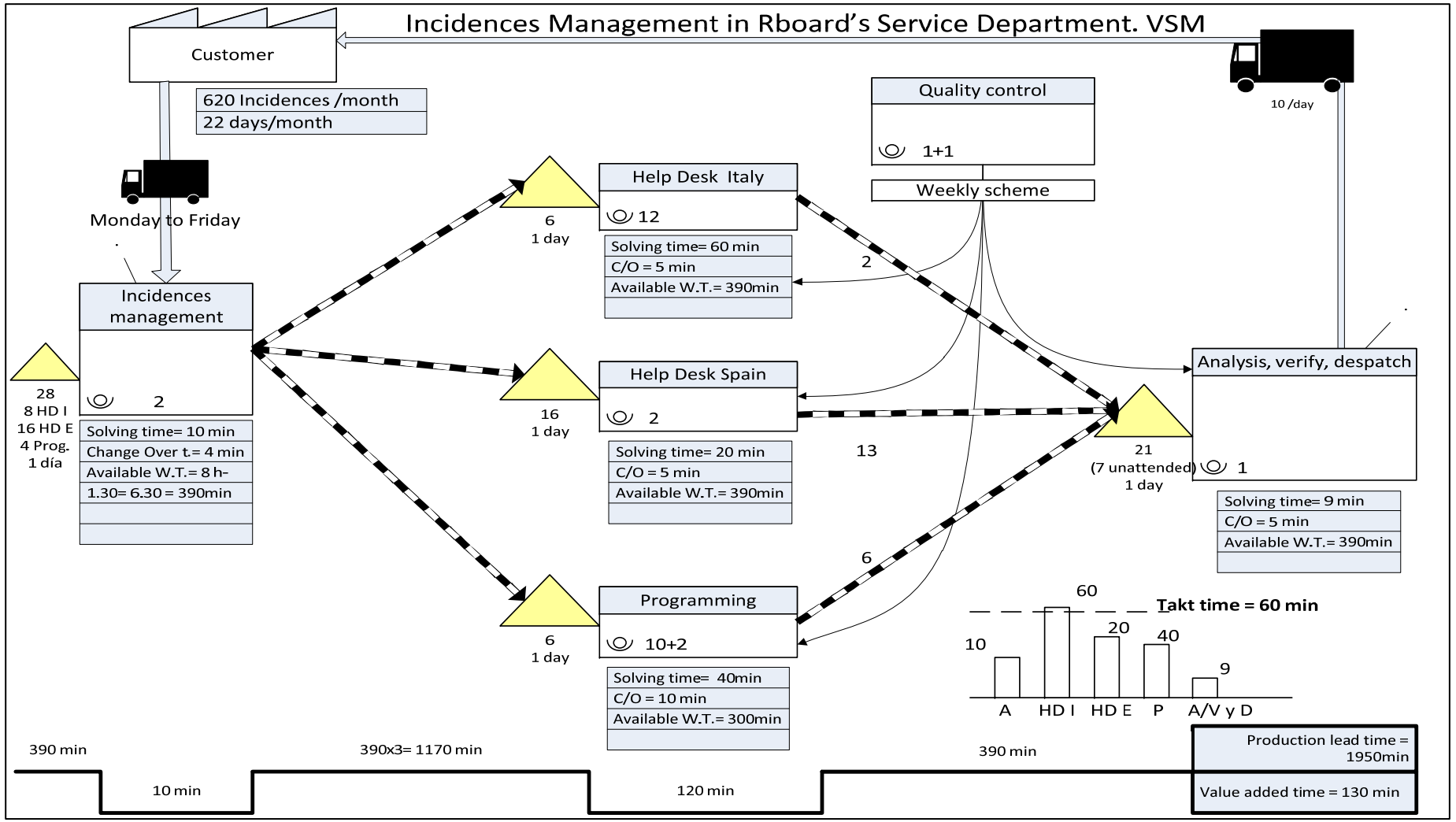

Fig. 5.3. Actual VSM of Service Department in Rboard.

CHAPTER 6. INCIDENCE MANAGEMENT IMPROVEMENTS

Previously, the incident handling process included four referred phases, which describe the complete sequence. Each of them does not have a well-defined boundaries and activities, so the overall process is cloudy and sometimes it involves endless loops. The main improve is to suggest a new transparent procedure to offer a solid structure in the process

Hence, it proceeds to propose five mayor and clear steps that begins when an incident reaches the Incident's team of the Service Department. The focus is to solve the root cause of incidents and to find permanent solutions for each one. Although every effort will be made to resolve the problem as quickly as possible, these improvements will be focused on the effective resolution of the problem and also in the speed of the resolution.

Using Lean process, as the main tool to reduce waste of time and ensure continuous flowing, the improvements will focus attention on define vital opportunities in each stage and sub-stage proposed in order to the check the cause of the problem and eliminates it before it spreads to the next phase.

The idea of introducing five phases in the incidence management is to simplify the amount of work in each one. Below, a description of each new stage proposed as an overall short-term improvement and, at the end of the chapter, the improved VSM.

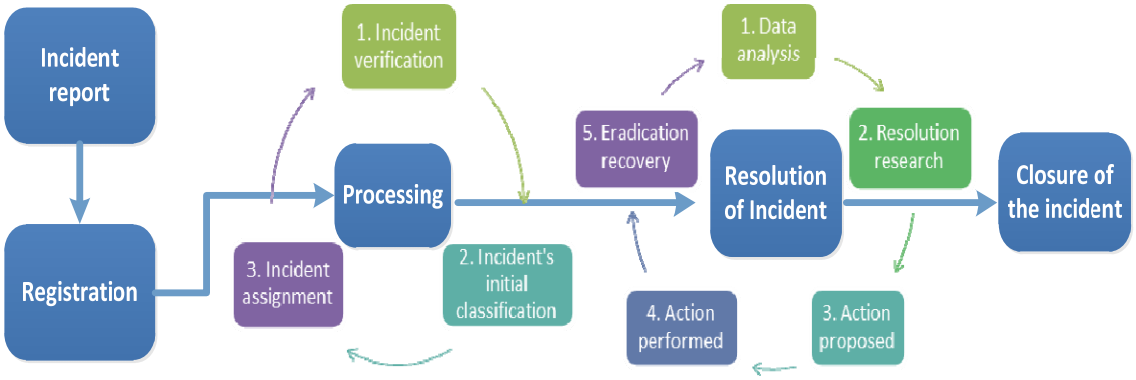

Fig. 6.1. Complete Incident handling workflow suggested.

6.1 Short-term improvements: New Stages

6.1.1 Improvement 1: Incident report

- Background: Key User of the Customer reports an incidence. There is not a

consolidated reporting channel. Experience shows that people do not like to use a unique channel. They prefer to simply send an e-mail or make calls. The most common way to do is by e-mail. It is not possible to store incidences out of labor time.

- Goal: as objective to start applying improvements is to recommend get incident reports only via the website incident reporting form. This is a standardized procedure and it offers automatized prioritization procedures.
- The Current State: the Incidence's team receives a report about an incident, in labor time, which can reach the incident handling system via several means of communication: e-mail, phone call and walk-in report, with no effective prioritization methods.
- Countermeasures: i) Pre-establish prioritization for customers, its needs and expectations, ii) assure automatized methods for reporting to new customers.
- Proposed situation: to implement completely the automated incident reporting using e-mail to the website, this is probably one of the easiest means of communication to link to the incident handling system. In this way, incidences can be received even out labor time and stored.
- Action Plan: i) Give training to customer's Key Users in the correct way to report incidences; ii) Adjust program and website for managing incidents.
- Indicators: The number of incidences received and stored in a period of time.
- Closing: this step is feasible to implement, using the actual software to handling incidents, even to program statics and alarms for weekends.

6.1.2 Improvement 2: Registration

- Background: it is mandatory to open an Incidence ticket for further fulfillment. Rboard's Service Department use an incident report registration that facilitates the registration process, adjusted to its own individual needs. This form is managed by the team in Italy but it couldn´t be reviewed in depth. It was informed that the reason is to avoid any leakage of information and/or avoid duplication of them. No pre-filtered nomenclature means incidences not registered properly, and then it makes overtime to classify each incidence for the new member included in this process
- Goal: as soon as the incident is received, grant a visual name.
- Current State: a report is formally registered in the incident handling system. This is linked to a 7 digit alphanumeric number of reference. For example, the naming for a recent incident is *215323C*. The incident handling system does this automatically. So it complicates a possible incident report related to an already-registered incident that the Service Department could decide to link or combine them together. In this stage is also implemented any pre-filtering mechanisms, e.g. for moving special kinds of incidents to a particular place or member of the team in the incident handling system.
- Countermeasures: i) Establish a scheme in which the name is related to name of the client, date and type of incident, obtaining a name easily manageable in the future. It makes subsequent and further incident processing easier, ii) to offer in this stage the possibility to link an incident to

a previous one or combine them as a unique incident.
- Proposed situation: the main recommendation is consider review this condition in the incident handling system. Otherwise it can expect a significant additional workload in managing it.
- Action plan: adjusting automated incident report in previous recommendation it is possible to adjust names to incidents.
- Indicators: reduced time in registration. Reduced time in later classification.
- Closing: the notorious visual notation for incidents will help to Service Department to receive and classify incidences in a standard way in both regional offices.

6.1.3 Improvement 3: Processing

- General background for all the stage: In current process, the *Processing* is along of all the time used to solve each incidence. Instead of this, the Processing phase suggested consists in three sub-phases: verification, initial classification and assignment. To implement Processing stage in the incident handling process, Rboard should prioritize the incident and progress it to diagnosis and resolution.

1) Incident's Verification

- Goal: get real incidences, avoid cases that concern to Key Users.
- Current State: at the verification step, a report is examined as to whether or not it concerns a real incident. The type of errors in incident reports has three main causes:
  1. There is no enough documentation that tabulates all the possible cases regarding to incidents, alarms, error codes and special conditions in the machinery, servers and mechanical systems. Each customer that works with an Rboard's solution has personalized software that is documented only in a 90%.
  2. The solvers (and Customer's Key Users) don´t remember the manual or previous instructions, so if the possible incident is repeated, it is handled as "Re-training procedure"
  3. If the manager of any sector is removed, replaced or on vacations, then the incident is not answered with a previous effective solution. This consumes time.
- Countermeasures: i) Focus on improve documentation available, ii) Make periodical trainings with Key users and Final users, iii) Pre-establish big topics to group incidences and to offer prior classification by the Key User.
- Proposed situation: sometimes inexperienced incident reporters send, for example, a system notification (e.g., main server reports a special condition that is not an error). If it is a single isolated case, the respond is kindly to such mis-reports but if there are a lot of them it consumes the resources. The best way to save time is to reject the handling of such a report. Rboard do not have to put extra energy into answering these reports. The solution could be an appropriate text in the automatic reply, which can be sending to incident reporters (Key Users). Also, considering that the incident handling inbox can contain a lot of information and queries about scanning activities,

it is almost impossible to handle all of such reports fully.

- Action plan: i) Improve and enhance manual users and procedures; ii) training to Key Users and main users in customers; iii) automate response system.
- Indicators: reduced time in processing. Reduced personal involved in this stage.
- Closing: Lean practices recommend reduce time and personal involved in each small process that could be automatized.

2) Incident's initial classification

- Goal: to deliver the best service to a customer. The factor to take into account in prioritization is the severity of an incident. In this case, prioritization mechanism must be simple: 1. - Very High and 2. - High priorities.
- Current State: Due to the number of incidences weekly, Rboard is not being able to manage every incident at the highest level of effectiveness. After verification, an incident is classified according to the classification schema. To decide how the incident is to be classified, Rboard's team tries to determine as much information as possible from the report (and possibly other known reports). This is not an easy task as, at this stage, the team usually does not have enough data to do it properly. Nevertheless, it is important to classify the incidents at this stage to look forward the proper team that would attend the incidence.
  The 100% of the level 1 incidents are solved in time (less of 24 hours), but a 90% is not solved in time for level 2. The ratio between quantities of each level is 80% for level 2, 20% for level 1.
- Countermeasures: i) To differentiate the level of service into two different categories, according to its prioritization; keeping in mind the main tasks and missions accorded in the commercial contracts for an incident handling service.
- Proposed situation: For practically all the SLA customers, it delivers a priority 1 service – that is, the high priority. Rboard only react with the highest priority to the most severe incidents. For the rest of the constituency it delivers a 'good effort' service with special care for incidents of severity level 1.
- Action plan: Establish clear prioritization schemes, differentiated by urgency and SLA accorded to each customer.
- Indicators: Both levels of priority must be solved at 100% in less of 24 hours.
- Closing: The objective is to restore the service as quickly as possible to meet Service Level Agreements. The process is primarily aimed at the user level.

3) Incident's assignment

- Goal: reduce time assigning incidences.
- Current State: in the Processing phase, Rboard's Service Department assigns an incident to an incident handler (solver). As first step, there is a main condition: if the client is Italian, the case is attended by an Italian team.

If the case is in Spain, the team is attended by a Spaniard team or Italian. After that, simply decide the specialized handlers for particular types of incidents or finally have an incident handled by more than one handler according to their availability, specialization or other factors. There are two types of teams in Service Department: specialized programmers and IT technicians.

- Countermeasures: the main improvement that could be implanted here is to hire another technician (IT engineer) to satisfy all the actual and future incidences. This suggestion has been validated by the surveys. Additionally, the new system must archive in storage the incidents that appear in weekends and no-labor days.
- Proposed situation: Avoid depending of Italian team to solve incidences originated in Spain.
- Action plan: i) Hire, at least, one IT engineer in Spain; ii) adjust software to each Solver capabilities.
- Indicators: reduced time between receive an incident and the assignment.
- Closing: this improvement will be detailed in the new VSM as a PULL system. Overburdening of personal (*Muri*) must be avoided, according to Lean.

6.1.4 Improvement 4: Resolution of Incident

- General background for all the stage: this should be the longest phase, which leads to the resolution of the incident (or at least it should). It is made in the basic cycle: data analysis, resolution review, action proposed, action performed, and eradication and recovery. Sometimes, when the reporter (Key User) can't define the incident properly or the type of incident is new, instructions for the Italian team are required, so the Processing stage lasts more than this stage. This situation had a proposed solution previously.

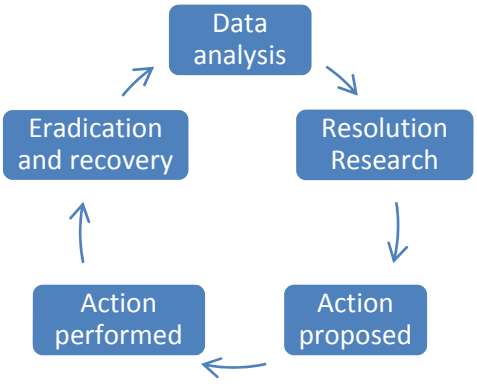

Fig. 6.2. Cycle followed in the resolution of Incident stage

1) Data analysis

- Goal: once defined the source of the incidence, collect data successfully.
- Current State: In practice, solving the incident is practically impossible without involving many or all of these parties. Contacting them and working with them require many repeated activities. Sometimes contact is easy and

a party is very responsive and helpful, but many times the local team has to be really persistent in order to obtain a single piece of information from the Italian technical team that is vital to solve the incidence. Having completed the notification and data collection tasks, it can now start data analysis. To start data analysis, first the company has to notify the parties involved and collect data from them. First inform those who may be the most affected. This notification includes some initial advice and information about further proceedings to resolve the incident.

- Countermeasures: i) To start data analysis, first the company has to notify the parties involved and collect data from them, informing those who may be the most affected. ii) The notification must include some initial advice and information about further proceedings to resolve the incident. This must collect as much data as possible, iii) there are several main sources of such data:
  - Rboard's monitoring system
  - Existing databases.
  - Incident reporter experience
  - Italian technical experience
- Proposed situation: It is important to distribute this work properly within the team. In general, it considers two factors: a team member's expertise and a team member's current workload. The proper adjustment of these two actions will make and special improvement in the quality of service.
- Action plan: i) with a well pre-filtered incidence it can be assigned to the proper solver; ii) give periodical training to Help Desk team.
- Indicators: an identified route followed by each solver can be described in Incidence's historic; then with it, the quality of data collected can be measured.
- Closing: the success of solving an incidence very much depends on this part.

2) Resolution review

- Goal: reduce part of the time used in each incidence.
- Current State: the information is collected among all the possible observations that they contribute and the incident solver decide which ideas he will use for the resolution of the incident. No collaborative teams are present. Even better equipped members don't share information as they should.
- Countermeasures: i) During the data analysis phase, people must be collaborative exchanging their ideas, very often between Spaniard and Italian teams.
- Proposed situation: The collection of data must be the just amount of it to avoid much more data and to limit the dependence of Italian teams, hence reducing time in solving.
- Action plan: i) Establish internal incentives to Help Desk Members; ii) commitment to Managers to pay more attention to solvers requirements; iii) standards procedures and manuals are necessary to avoid constant change of information between regions.
- Indicators: An identified route followed by each solver can be described in Incidence's historic; then with it, the analysis phase time can be measured.

- Closing: Both Help Desk teams want more training in quality services and standards.

3) Actions proposed

- Goal: effective and short answers in solutions.
- Current State: each part in each client requires a special language and attention, so it is important to take into account the personal value that the solver member of the team can contribute on it.
- Countermeasures: the incident solver must prepare a set of concrete and practical tasks for each part involved in the case.
- Proposed situation: the solver must be able to manage languages from advanced technical terms until descriptive basic mode, in order to be sure that the incident owner understands the proposed set of actions.
- Action plan: i) Is required training in quality management.
- Indicators: an identified route followed by each solver can be described in Incidence's historic; then with it, the effectiveness can be analyzed.
- Closing: For more clarification, it is useful to develop a short list of possible actions for the customer.

4) Actions performed

- Goal: to take advantage of actions that does not work at first time.
- Current State: in practice most of the actions proposed will not be executed properly, because the parties are not under total control of the solver. Often they read a set of instructions by e-mail, so they do not act appropriately on the proposals. Often the Key Users read a set of instructions by e-mail, so they do not act appropriately on the proposals.
- Countermeasures: i) Follow up actions proposed only if it is required, ii) do not open a new ticket for already problems solved.
- Proposed situation: The technician must be able to monitor the execution of the actions by the traditional means, as phone, remote control or Skype™.
- Action plan: when the solutions are not working properly it is a good time to firm up the relation with the customer.
- Indicators: Carry out external surveys for measure customer satisfaction levels.
- Closing: it is important maintain a closer relationship between Service Department and Customers. Also, tasks get involved with the customer can be done when the team has free time.

5) Eradication and recovery

- Goal: the main objective pursued must be the total eradication of the incident, in a customer and in all the actual and possible future customers.
- Current State: once solution is proposed, tested but still do not checked. The Solver asks repeatedly to the Customer for more relevant information, which incurs in waste of time.
- Countermeasures: to test and check solution without customer intervention.
- Proposed situation: It is a suggested practice to Rboard to check as much

as possible and get a positive confirmation form each party that in their opinion everything is operating normally again.
- Action plan: i) Store solutions in database; ii) complete manuals with previous solutions; iii) create in the webpage question-answer help customized for each customer.
- Indicators: i) Reduce unsolved incidents to 0% in 24 hours. ii) Carry out external surveys for measure customer satisfaction levels.
- Closing: The real resolution of a problem is to recover or restore to normality the service that was affected during the incident.

6.1.5 Improvement 5: Closure of the Incident

- Background: solutions remain in Database as “not solved”, even the Key User already has the solution. Sometimes it occurs that customers are not warned properly for ticket closed, or even other solvers are working in a problem that has been solved.
- Goal: once the incident resolution cycle is left behind, only solver is capable to close it properly.
- Current State: Key User has to close the ticket by itself. In some occasions it has to ask several times for solutions.
- Countermeasures: once the solution is tested and checked, close the ticket and inform immediately the solutions set to the Key User involved.
- Proposed situation: the closure inform must include a short description of the incident, including its classification for further references, the results of the solver, if it was resolved properly or not and notes about recommendations.
- Action plan: close tickets must generate an automatic alert to the customer and other solvers in Help desk team. Adjust the program and methodology of closure.
- Indicators: time life of each ticket. It must be reduced in 30%.
- Closing: This correct procedure offers to the Customer a clear vision about the Customer Service System of Rboard, improving the quality of the service.

6.2 Long-term improvements

The aim of a Control phase is to gain a long-term good performance, reducing the waste previously mentioned. Without this phase, the short-term improvements for the process will turn back to its original status, and the improvement result will not last too long. In any case, these activities will leads to the management team to continue with the methodology proposed in a long term application:

- Lessons learnt during improvement should be stored as a part of the company asset.
- Apply improvements. Control tool: checklist to audit if processes are properly followed or not.

- Conduct external surveys to evaluate performance.
- Implement standardized protocols in regions to avoid problems happen again.
- Conduct new goals for further improvements.
- Spread successful Six Sigma ideas to other departments or projects.
- Create its own Six Sigma projects guidelines for the future.
- Enhance operators' sense of quality in service.
- Conduct more training about standard operations

To implement a strategy for continuous improvement is mandatory. Although the process has been improved and the problems have been solved, is not known whether the process will turn back to its original statement. Furthermore, the improvement of quality will never end. To keep a long term improvement and to avoid the solved problem happens again, setting down a strategy is necessary to keep continuous improvement, for instance, establishing standards to standardize Help Desk employee's behavior.

In the other hand, in this project of improvements, there were main problems trying to observe the DMAIC methodology and Lean concepts for the Service Department:

- Until now, non-standardized procedures had been utilized.
- Inconsistency in document control, as well as the maintenance of service process and incident's performance records.
- When work within incidents, they were taken over by a different member of staff; therefore, many steps had to be duplicated to ascertain exactly what had been done on a case. Duplication and rework caused capacity to be employed in unproductive efforts (*Muri* concept)
- Different regions are not adopting unique methods to perform work resulting in unique capacity planning methods and uneven utilization. (*Mura* concept).

6.3 Improved VSM diagram of Incident Management process in Rboard's Service Department.

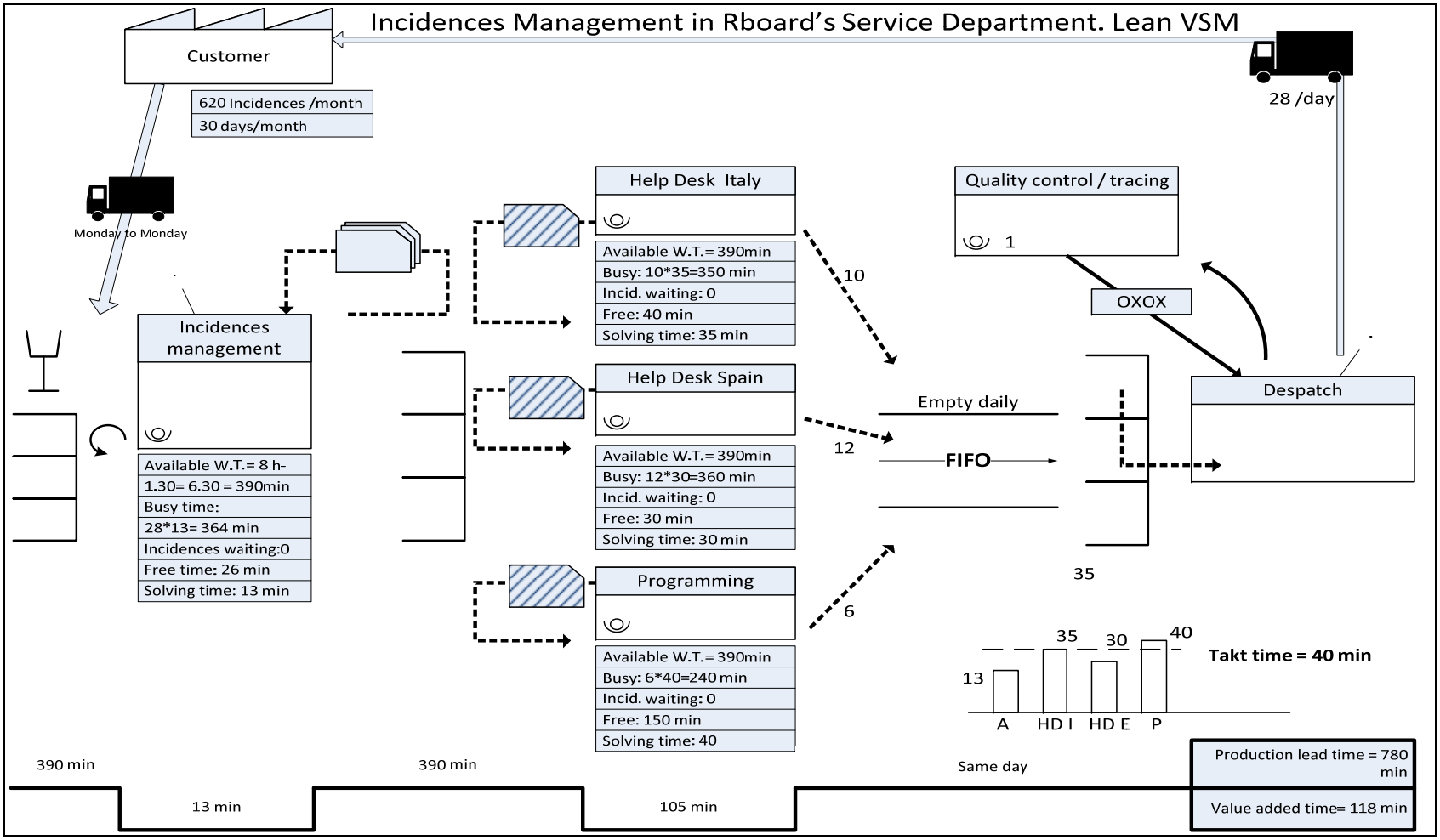

Fig. 6.3. Improved Lean VSM of Service Department in Rboard.

CONCLUSIONS

This project has followed a method for Lean Six Sigma implementation to find improvements in service process. It is proven that service companies can follow steps in this method to apply Six Sigma approach to improve their processes.

To show the state-of-art of Six Sigma approach, author has conducted one Service Department's interview and analyze two case studies which came from service and other fields. In this interview and studies process, author found an amazing coincidence. The usage of Six Sigma approach in those interview and cases are almost same, including the selection of methodology and Six Sigma activities. This finding gave a big help on generating the general method for Lean Six Sigma Service implementation.

According to the documents analyzed the methodology of developing, implementing an maintaining a Lean Six Sigma Methodology at this organization was slightly different from the literature in a sense that only three phases were used, which the literature regards as fundamental: Define, Measure and Improvement phases.

Also, regarding to the analyzed documents, this Company undertook an operational capability analysis to improve business performance and build steady state operations within the offices and across different regions. This exercise revealed that there was little uniformity in the manner in which the work was conducted. The analysis also showed that the operational environment was characterized by disparate islands of processes and information with different offices, regions and business areas operating divorced from each other. Although in some processes there were existing procedures that had to be followed, they were not carried out in a standardized and consistent manner as their roll-out and implementation was not done in a systematic way.

Another connection, according to the main author in Lean Six Sigma, Michael George [6], the slow rate of corporate improvement is not due to lack of knowledge of Six Sigma or Lean. Rather, the fault lies in making the transition from theory to implementation. Managers need a step-by-step, unambiguous roadmap of improvement that leads to predictable results. Analyzing the successful application of this methodology in cases reviewed, it took at least 5 years of try and review to tune in the procedures of whole company.

The reasons for adopting Six Sigma are clear: fewer defects, faster delivery and increased customer satisfaction [3]. Lean helps to identify wastes. The more familiar with the incident process is the management, the higher productivity is obtained.

The differences between Service and Manufacturing are obvious and unavoidable. Despite of manufacturing product can easily be measured as weight, distance, quantity, etc.; the service characteristics such as defects number or Mean Time Between Failure (MTBF) usability cannot be simply measured. Even the Cycle Time concept is changed by Working time, Availability and MTRS, hence Six Sigma approach can be applied in service

departments and companies if we involve the right people, solving the right problem, and using the right method. At the same time, although using Six Sigma approach for process improvement does not costs a lot, it worth. Few incidents, faster attention time and increased customer satisfaction will generate more potential profits than is thought.

Since Six Sigma focuses on the quality from the beginning of a project so it has minimal cost to improve quality. On the other hand if it waits up to the testing phase in finding the defects then the cost to fix the defects is very high. A cost and benefit analysis should be done in the Six Sigma program to determine the actual gains.

While investigated the concept of Six Sigma approach, author found that Six Sigma approach had three forms for quality improvement. The first form is as a metric which equals to 3.4 defects per million opportunities. This is a requirement for the highest quality level. The final aim of Six Sigma is to reach this defect degree. The second form of Six Sigma approach is as a methodology. It basically provides two models for process improvement. DMAIC model is used for existed process improvement, while DMADV model can be used in new process development. The last form is as a management system, which is binding with company's business strategy.

Six Sigma is best used in process or production industry, and many of the statistical tools have a direct and good use. The challenge was to employ Six Sigma in Service processes. The main challenge was to identify the CTQs metrics, be able to identify root causes, and measure improvements. Another challenge was that the processes used have irregular long life span and the processes are furthermore not to be easily classified as stable and repeatable.

Then the analysis resulting is mixed into a method for applying Six Sigma approach the Service Department. Two main parts are involved – environment establishment and the enhanced methodology. The first part provides to Service Department a top-down introduction for Six Sigma framework. By learning that, the Service Management team can build its own framework. The other part is an enhanced methodology. Previous authors have integrated lessons learned from the analysis with the DMAIC model, which makes the model contain Service characteristics. This method is believed can handle all general cases.

Then DMAIC has been selected as a model for organizing this Six Sigma project. Analysis findings and service properties have been integrated with the selected model. Its functionality has been enhanced to meet company requirements on incidence attention. Activities and quality tools were blended with each step in each model phase. By the purpose of practicability and authenticity, most of them came from interviews and case study reviews. As a final conclusion, Rboard needs to establish some necessary standards or rules to keep continuous improvement.

In essence, this analysis provides an initial roadmap that tells the Lean Six Sigma implementation team: "Where do I start from?" "What to do?", "How to do?" and help them in doing the first steps in this successful methodology.

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ANNEXES

TITLE: Proposal of a Lean Six Sigma methodology implementation in a Service Process.

MASTER DEGREE: Master in Science in Telecommunication Engineering & Management

AUTHOR: José Ramón Barillas

DIRECTORS: Jordi Olivella Nadal and Gema Calleja Sanz

DATE: March 17th, 2014

ANNEX 1. INTERVIEW PATTERN

Name:
Age:
Office:

DEFINE

- Clear performance objectives namely
- Criterion of quality of service
- Speed of delivery of service
- Dependability and reliability of the service provided
- Flexibility of the service provided and reduction of costs (the main goals that the organization's operations seek to achieve.)

MEASURE

- Is quality in service a performance measured internally or externally?
- Do you think operational strategies support its vision and problems? (No for CEO)

ANALYSIS

- Tell me how you analyze and plan to solve the problem specific
- Does your team understand and accept the performance expectations? (CEO)
- Does your team feel it is possible to achieve their personal objectives? (CEO)
- Do your subordinates feel that high performance is more rewarding than average or low performance? (CEO)
- Do your subordinates feel the rewards used to encourage high performance are worth the effort? (CEO)
- Are rewards administered on a timely basis to your team as part of the feedback process? (CEO)

IMPROVEMENT

- The Six Sigma implementation comes up with new way of doing things; it is therefore advisable for a change management program to be implemented concurrently with the development and implementation of a Lean Six Sigma program. Do you think that the implementation of improvements require change management?
- If it is yes, what kind of change management programs was implemented?

CONTROL (no applicable completely)

- Do you think the employees will be involved during the early stages of development a new program, like Six Sigma?
- If yes, how were they involved?
- Do you think top management is involved and committed to the implementation of quality standards?
- Do you think employee's involvement would impact on the quality in service?
-

ANNEX 2. QUESTIONNAIRE PATTERN

Name: [Optional]
Age:
Office:

DEFINE

- How do you identify the problems which need to be improved?
- Who will be involved when deal with a specific problem? How to distribute roles and responsibilities?
- Do you think implementation of Six Sigma would be useful?
- How do you think the customers observe the organization? Dependable, reliable, effective?
- Do you think the organization led to innovative services and flexibility of operation?

MEASURE

- Tell me how you measure the problem conditions?
- What measure is put in place to ensure continual improvement?
- Did implementation of solutions lead to individuals or groups applying the quality methods to identify the problems in the processes? (These involve identifying output variations, intervention to minimize deviations from quality standards)

ANALYSIS

- How do you analyze and plan to solve the problem(s)?
- Tell me how do you estimate the cost of the change, if any?

IMPROVEMENT

- Tell me how do you implement the plan? (if there any) Is there critical issues?

CONTROL

- Tell me how would you monitor and record the implementation of improvements.
- What kind of commitment is demonstrated by top management? (No CEO)
- Do you think that in short time a program can improve the general performance of this department?

ANNEX 3. INCIDENCES MANAGEMENT SOFTWARE

Fig. 3.1 Incident Manager installed in a server. It should be installed in each Help Desk member team. Also note only two automatized incidences are generated by RPM and sent via e-mail.

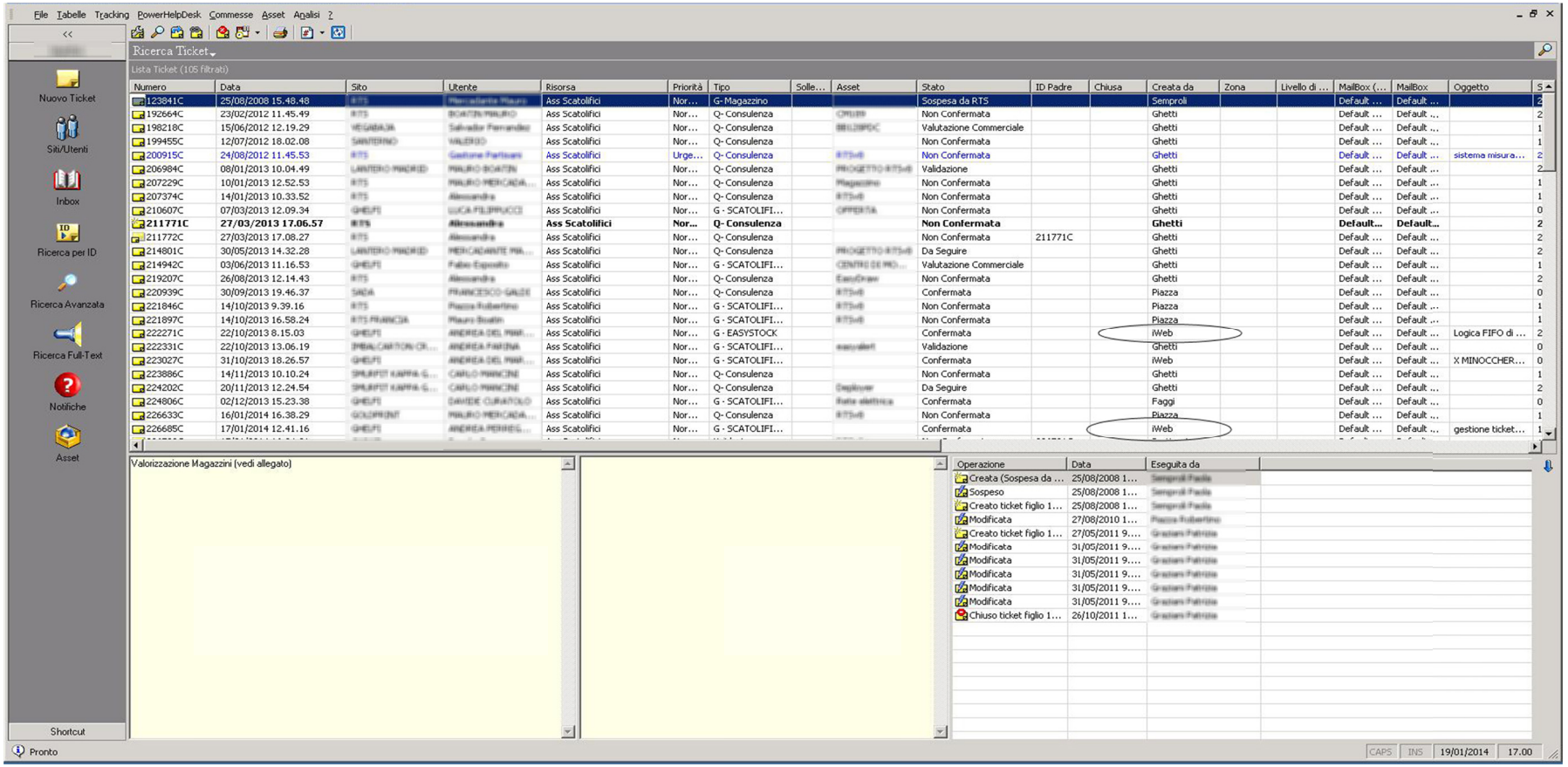


Fig. 3.2 Incident Manager. Incidences filtered by Helper. Note the Urgencies and Status classifications. The last one is used to redirect the Incidence to a specific Department.

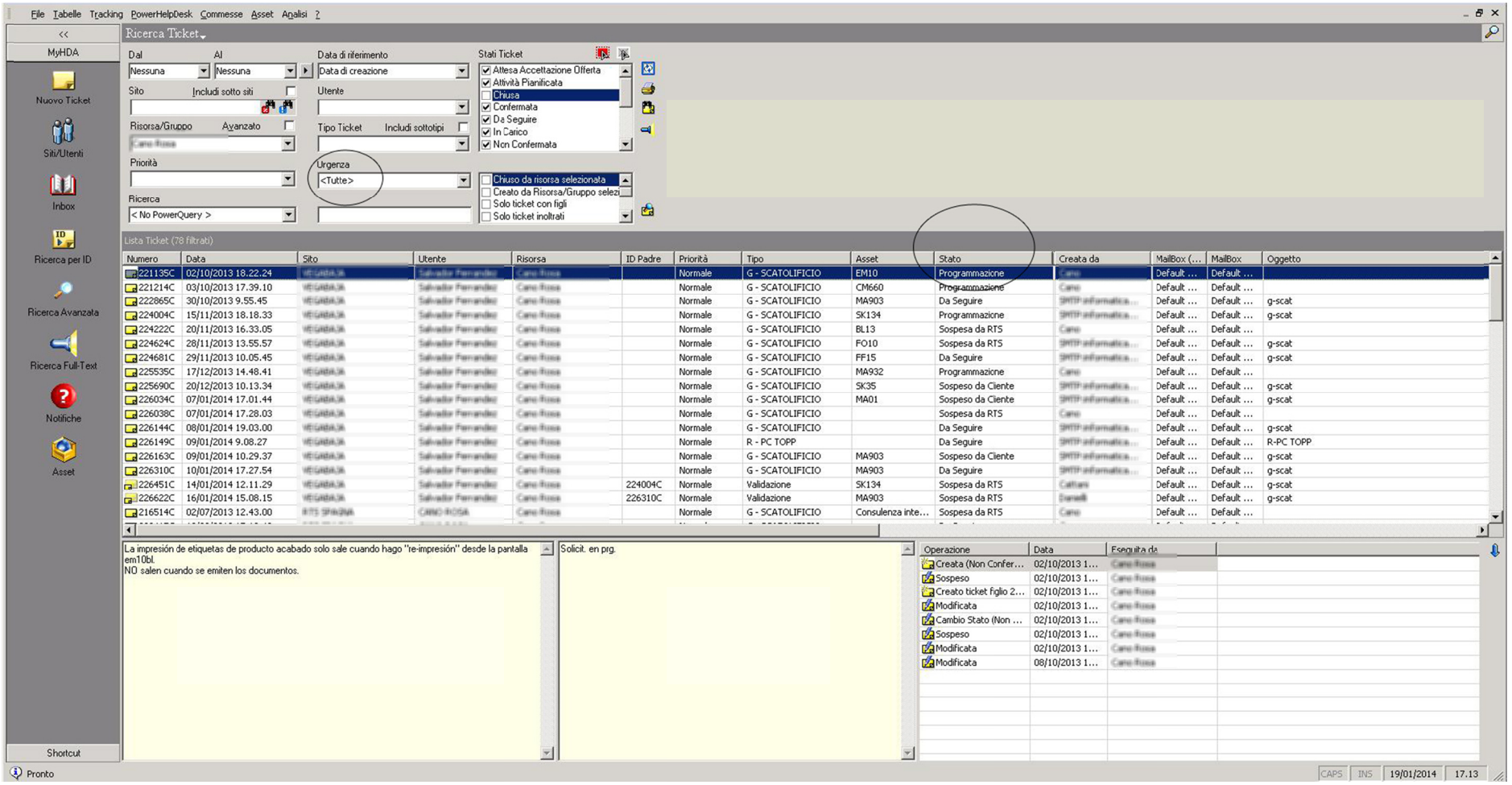
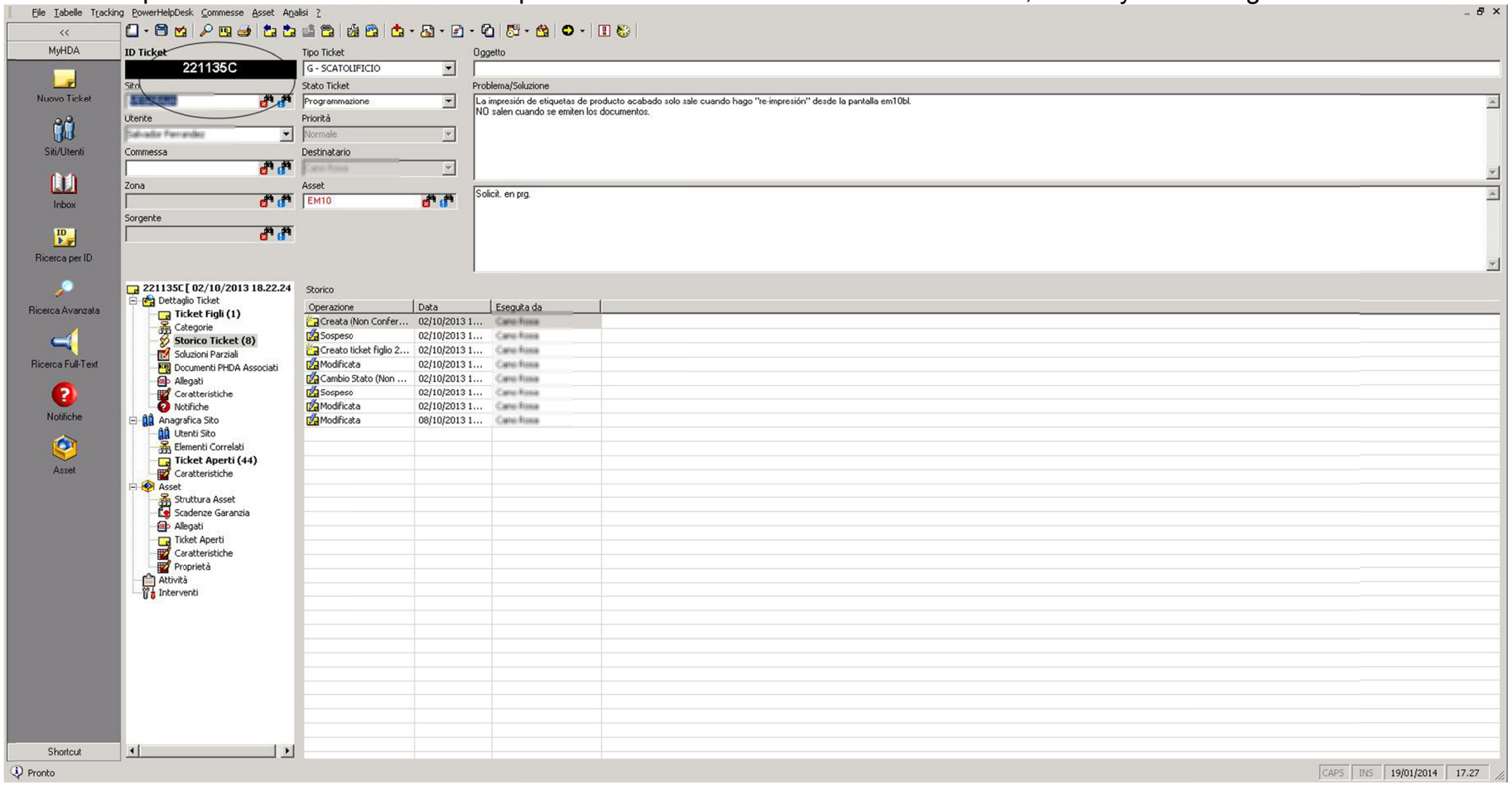


Fig. 3.3 Incident Manager. Incidence opened. The name assigned and the historical details of this Incidence are shown. There is a space to add comments from Helper that could work in further classifications, not only for solving.



ANNEX 4. TYPES OF WASTE

This list is developed combining different authors' viewpoints. Firstly, the seven types of wastes are identified and described to let the reader understand the meaning in terms of manufacturing and service perspective. Then it follows with some examples in different kind of organizations. After explaining the seven types of wastes, another new waste in service is described followed with examples.

Table 1. Types of waste.

Waste type	Description	Examples
Transportation	Manufacturing perspective: It is the movement of materials which is not needed, because their chance to get damaged and deteriorated increases [10].	●The movement of materials on and off site without a need; and movement of intermediate product in the site [2].
	Service perspective: It means the movement of materials and information, which should be reduced for activities that do not add value, or are related to occurrence of waiting time and queues that dissatisfy customers [6].	●In banks, many people face the problem of transportation because they have to collect materials and information by asking different people until they reach the right person [6]. ●In healthcare, it can be the distance of transport of test samples because of the centralized resources in organizations [12].
Motion	Manufacturing perspective: It happens when there are unnecessary movements of people and machines [10].	● Double handling of materials in the organizations [10].
	Service perspective: It does not add value to services, because it only takes additional time and cost related to unnecessary movement of employees. The motion is very hard to measure in service sector [6].	●People have to go from one computer to another to complete a task [6]. ●Searching for people and equipments which are placed within long distance [12].

Over processing	Manufacturing perspective: Organizations using big machines, which are not efficient with low quality that causes defects. So, organization should focus on long term and purchase smaller and simpler machines that fit to the capacity needed based on customers' demand [10].	●The variation between operators, which causes the machine to be used for several lines [10].
	Service perspective: It includes excess costs with attempt to add more value to service than is needed to satisfy customers [6].	●If a store wraps clothing item in a layer of tissue, this might work in boutique that target high income people, but not in retail stores where people want to pay as less as possible [6]. ●In healthcare, acquiring numerous test samples from patients, which are unnecessary [12].
Inventory	Manufacturing perspective: It involves the over existence of raw materials, WIP and finished goods in organizations. This is considered waste because of the excess of cost spend on them [10].	●The excess of inventory compared to the quantity that was specified them [10]. ●Large warehouse occupied with inventory in the site. When employees are unable to provide services according to customer's requirements due to lack of supplies them [10].
	Service perspective: It means using excess inventory instead of what is actually required to provide service to customers. This should be avoided because it does not add value to customers and involves higher cost of waiting. This kind of waste is usually a result of overproduction [6].	●Providing substitute of products or services, not what was asked by customers them [10].
Defect	Manufacturing perspective: It involves any waste which involves costs related to delay, warranty and repairs [10].	●Rework, customers' complaints, or even loss of customers [10]. ●Higher operating costs [10].
	Service perspective: It happens when services are not performed	●A lack of information or inaccurate process of documentation can cause delays which dissatisfy customers

	within specification of customers. Some of the services are not costly to correct mistakes, but organizations should consider that they might also lose customers [6].	[6]. ●In healthcare, infections that patients get due to lack of hygiene and poor treatment [12].
Waiting (time on hand)	Manufacturing perspective: It is considered an enemy of flow, because materials and components do not move as a result of waste [10].	●Operators or employees waiting for something; materials waiting in a queue; and late delivery [10].
	Service perspective: It involves a delay in one activity, which causes a delay in the following activity. The value stream mapping technique is useful to identify process delays. Organizations can analyze the waiting time by looking at each activity in the process to identify delays [6].	●Waiting in the meeting for people who show up late, which lead to irritation and loss of time in which work could be performed [12]. ●In healthcare, patients waiting in the queues [12].
Overproduction	Manufacturing perspective: It involves producing too much, or just in case it is needed without being focused on customers' demand. This leads to excessive lead times and deterioration of products [10].	●The area of space that is needed and used in the warehouse [2].
	Service perspective: It means the excess production of service outputs [6]. This happens because organizations produce more services than customers want.	●Entering unnecessary information for organization [12]. ●In healthcare, patients are admitted to the hospital and they wait because there is no time to give them service till later [12].
Unused employee creativity	Service perspective: It happens when organization losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to their employees [2].	●The loss of skilled employees that could contribute for organizational improvement [12]. ●Not using the creativity of people; not paying attention to ideas of employees, but only managers [6].

ANNEX 5. ITIL FRAMEWORK

IT Infrastructure Library (ITIL®) is a collection of best practices produced by UK Office of Government Commerce for IT Service Management (ITSM). It provides a framework for the governance of IT service and focuses on the measurement and continual improvement of the quality of the service delivered from both a business and a customer perspective (ITIL 2007). ITIL describes procedures, asks and checklists suggested for use in organizations for establishing a minimum level of competency for Service Management, so that the organization an plan, implement, demonstrate compliance and measure improvement. (ITIL Official site) This process-based framework is adopted in many organizations.

Since its start in the late 80s, several ITIL versions have been produced. However, the core approach to the ITIL guidance stays unchanged and consists in five basic processes: Service Strategy, Service Design, Service Operation, Service Transition and Continual Service Improvement. These processes represent an ITIL service lifecycle, each of the five influencing and relying on the others. Figure 4.1 illustrates the processes of ITIL framework.

As seen from Fig. 5.1, the lifecycle of an IT service starts at the Service Strategy stage where the business needs and requirements for a service are set, and then it circulates cyclically through the Service Design, Transition, Operation and Continual Process Improvement. Every stage of a service's lifecycle has an in-built continual feedback system to guarantee that the service is able to provide business with the measurable value continuously. This procedure is similar to the Lean methodology, which requires continuous improvement.

Fig. 5.1. ITIL framework. Source [16]

Incident Management

Incident Management (IM) is the ITIL process for dealing with incidents, which can be a query, question or failure (existed or possible one) related to a service.

Thus, the main goal of Incident Management is to restore service as soon as possible and to minimize impact of incidents on business to ensure the best possible quality and availability level of a service. By incidents, ITIL means any unplanned interruptions to an IT service or a reduction in its quality (ITIL 2007).
Incidents can be reported by users, technical staff and event monitoring tools. When dealing with incidents, the main concepts associated with them are Impact, Urgency and priority level [16].

IM is primarily a reactive process, its processes provide guidance on diagnostic and escalation procedures required to quickly restore services.
Incident Management activities include [18]:

- Detecting and recording incident details
- Matching incidents against known problems
- Resolving incidents as quickly as possible
- Prioritizing incidents in terms of impact and urgency
- Escalating incidents to other teams as appropriate to ensure timely resolution.

Incidents and Service Requests are formally managed through a staged process to conclusion. This process is referred to as the "Incident Management Lifecycle". The objective of the Incident Management Lifecycle is to restore the service as quickly as possible to meet Service Level Agreements. The process is primarily aimed at the user level [17]. In this project, the Incident Management is used as a reference to give a structure to the process observed and defined in Rboard's Service Department.

ANNEX 6. SIX SIGMA DMADV MODEL

DMADV (Define, Measure, Analyze, Design and Verify) model was developed by Thomas Pyzdekis. This model is applied to the development of new processes or products. The phases of DMADV are described below [26]:

- Define phase is to find out the customer needs and expectations and to define the project scope.
- Measure phase is to identify the CTQs (critical to qualities), process capability and risk assessment.
- Analyze phase is to develop the high level design concepts and design alternatives to select the best design.
- Design phase is to develop plans for test verification, this may require simulations.
- Verify phase is to implement the process in operational scale.

ANNEX 7. Techniques and tools in Six Sigma

In this part, most of those tools and techniques will be explained. In the next table are shown the different tools generally associated with each respective phase of DMAIC methodology. The functionality of main tools is described further.

Table 2.1. Distribution of tools in Six Sigma [6, 27, 30, 31].

Phase of Six Sigma	Tool
Define	Cause-effect Diagram, Pareto Chart, Brainstorming, Affinity Diagram, SIPOC Diagram
Measure	Flow Chart, Histogram, Check Sheet, Spreadsheet, MSA, VOC Method
Analyze	Flow Chart, Pareto Chart, Cause-effect Diagram, Histogram, Control Chart, Process Mapping, Kano Analysis
Implement	Scatter Plot, Control Chart, Project Management Methods, FEMA, Stakeholder Analysis, Process Documentation
Control	Control Chart, Flow Chart, ANOVA, Correlation and Regression, DOE.

7.1 Check Sheet

The check sheet is used to collect data of the desired characteristics of a process that should be improved. If the collected data is incorrect, most efficient methods will result in a failure. In Six Sigma methodology it is used in the measure phase. The check sheet is represented in a tabular form. The check sheet should be simple and aligned with the characteristics that are to be measured [20, 27, 31].

7.2 Pareto Chart

The Pareto chart was introduced by Joseph M. Juran in 1940s. Juran named it after the Italian statistician and economist Vilfredo Pareto (1848-1923). There are several quality problems to be addressed in a project. Often the problems are solved one by one. The Pareto chart helps in deciding the order of problems in which they should be solved. Pareto chart is related to the 80/20 rule found in business economics. The 80% of problems are because of 20% of causes [20, 27, 31].

In the Six Sigma methodology, Pareto chart has two main functions. Firstly in the define phase it helps in the selection of the appropriate problem. Secondly in analyzes phase it helps in identifying the few causes that lead to many problems.

7.3 Histogram

Histogram is used in Six Sigma in the analyze phase. It is used to learn about the distribution of the data collected in the measure phase. Often we have huge data and each observation cannot be represented in figure. With the help of histogram the collected data is divided into different classes or intervals. The area of each rectangle in the histogram is proportional to the number of observations within each interval or class. So if we sum the areas of all rectangles it is equal to total number of observations [20, 27, 31].

When applying a histogram there should be at least 50 readings to get a good understandable shape of distribution. The number of intervals or classes should be between 6 and 12. To get the intervals it is good to take the difference of highest and lowest value in the data. If there are too many or too less data values or intervals then the histogram will be of a flat or peaked shape [20, 27].

7.4 Stratification

Stratification is used to divide the collected data into subgroups. These subgroups help in finding the special cause of variation in the data. It provides an easy way to analyze the data from different sources in a process. It is used very less as compare to other quality tools but it is beneficial. In the Six Sigma methodology it is used in the improve phase. The collected data is usually stratified in the following groups: machines, material, suppliers, shifts, age and so on. Usually stratification is done in two areas but if the data is large than further stratification is also possible [20, 27].

7.5 Cause and Effect Diagram

The cause and effect diagram is also known as fishbone diagram or an Ishikawa diagram. It was introduced by Dr Kaoru Ishikawa in 1943, while working in a quality program at Kawasaki Steel Works in Japan [20, 27]. Once we have a quality problem its causes must be found. Cause and effect Diagram helps to find out all the possible causes of an effect (problem). It is the first step in solving a quality problem, by listing all the possible causes. In Six Sigma it is used in the define phase and analyze phase [20, 27, 28, 31].

The reason that Cause and Effect Diagram is also called Fishbone Diagram is that it looks like a skeleton of a fish. The main problem is the head of the fish, the main causes are Ribs and the detailed causes are the small bones.

7.6 Control chart

The Control chart was introduced by Walter A. Shewhart in 1924. Industry is

using Control chart since the Second World War. It is also known as Statistical Process Control (SPC). In Six Sigma methodology it is used in analysis, improve and control phase. In analyze phase Control chart is helpful to identify that the process is predictable or not. In improve phase it identifies the special cause of variation. And in control phase it verifies that the process performance is improved. It shows graphically the outputs from the process in different time intervals.

There are two main purposes of Control chart. First is the creation of a process with a stable variation. The second is to detect the change in the process i.e. alteration in mean value or dispersion [31].

7.7 Scatter plot

Scatter plot is used to define the relationship between two factors. Its main function is to identify the correlation pattern. The correlation pattern helps in understanding the relationship between two factors. In Six Sigma methodology it is used in the improve phase. Once you know the relationship between the factors then the input factor values are set in a way so that the process in improved.

While constructing the Scatter plot the input variable is placed on the x-axis and the output variable is placed on the y-axis. Now the values of the variables are plotted and the scattered points appear on the figure. These points provide the understanding of the variables and the process can be improved. Often there are many variables affecting the process, in this situation a series of scatter plots should be drawn [20, 27].

7.8 Brainstorming

As defined by Alex Osborn [50], Brainstorming is "a conference technique by which a group attempts to find a solution for a specific problem by amassing all the ideas spontaneously by its members". It is designed to obtain ideas related to a specific problem as many as possible. It motivates people to generate new ideas based on themselves judgments. If the environment is comfortable and participants feel free to announce their minds, it will produce more creative ideas.

Brainstorming is a great way to generate ideas. During the brainstorming process there is no criticism of ideas which is to motivate people’s creativity. Individual brainstorming can generate many ideas, but it is less effective for each one’s development. This problem can be solved by group brainstorming which tends to produce fewer ideas for further development.

7.9 High-Level Process Map (SIPOC Diagram)

SIPOC diagram is a Six Sigma tool which is used to identify all process related elements before we start to work. Predefine those factors can avoid we forget something which may influence the process improvement, especially in complex projects. SIPOC is the logograms for “Suppliers, Inputs, Processes, Outputs, and Customers”. All the works are to:

- Identify suppliers and customers who will influence the projects.
- Obtain the inputs for processes from suppliers.
- Add value through processes.
- Provide outputs to meet customer’s requirements

7.10 Affinity Diagram

The affinity diagram is developed by Kawakita Jiro [52], so it is also called KJ method. It is used to organize large number of data into logical categories. Generally, we use affinity diagram to refine the ideas generated in brainstorming which is uncertain or need to be clarified. To create an affinity diagram, we need to sort the ideas and move them from the brainstorm into affinity sets, and creating groups of related ideas. Below issues should be followed:

- Group ideas according to their common ground. The reason can be ignored.
- Using questions to clarify those ideas.
- If an idea has several characteristics, we should copy it into more than one affinity set.
- Combine the similar small affinity sets into one, and break down the complex sets.

The final result of affinity diagram shows the relationship between the ideas and the category, which can help brainstorming to evaluate ideas. And it is also considered the best method for the ideas without speaking.

7.11 Voice of the Customer (VOC) Method

Voice of the customer method is a process to identify customer’s requirements for high quality product. The customers come from different fields. External customers usually are common customers, suppliers, product users, partners, etc. And internal customers include employees from market department, product development department, and so on [30].

There are several ways to capture the voice of the customer – individual or group interviews, surveys, observations, customer specifications, complaint logs, etc. Through these methods, we can get the stated or unstated needs from the customer. By assessing and prioritizing those collected requirements, it provides ongoing feedbacks to the organization.

7.12 Others

The other methods are seldom used, but still very helpful. They are

- Project Management Methods – The project management skills can significantly help the Six Sigma improvement projects, such as project planning, project charter, scheduling, communication, HR management, and project management tools.
- Failure, Effect and Mode Analysis (FEMA) – The main work of FEMA is to assess risks and put efforts on controlling and minimizing risks. Before work with those risks and identify their causes and effects, using flow chart to prioritize them in the timely sequence is a nice choice.
- Process Documentation – Effective, clear, comprehensive process documentation is very helpful for the Six Sigma projects, such as process maps, task instructions, measures, etc.
- Stakeholders Analysis – Identifying the people who have a stake on the Six Sigma process improvement project. Those people will directly or indirectly influence the projects or results. The ones who are not satisfied will insist to changes.

ANNEX 8. DATA RELIABILITY AND VALIDITY

Reliability is a statistical measure of how reproducible the survey instrument's data are, whereas, validity is assessment of how well a survey or index measures what it is intended to measure [21]. Reliability is the degree to which results are repeatable, and this applies both to subjects' scores on measures and to the outcomes of the study as a whole. The same set of results will be obtained repeatedly in replication of the study if the study is reliable. Since positivists believe they are studying a stable and unchanging reality, reliability is a highly valued criterion that indicates how accurate and conclusive the findings are [20].

Validity is the degree to which a measure does what it is intended to do. This means that the measure should provide a good degree of fit between the conceptual and operational definitions of construct, and the instrument should be usable for the particular purpose for which is designed. If the findings are true for all humans, and for all operationalization of the measures used in the study, then the study possesses complete external validity [22].

According to [22], in surveys, error comprises two components, namely, random and measurement error. Random error is the unpredictable error that occurs in all studies, which may be caused by many different factors but is affected primarily by sampling techniques. There might be reliability and validity errors, to mitigate this; one may select a larger and more representative sample, which will increase the cost of the study, so it is often neither practical nor feasible simply to expand the sample.

Measures were taken to ensure that the reliability and validity of the results of this study was ensured, and the error rate was minimized as much as possible. This study was subjected to serious time constraints, which may have impacted on the reliability and validity of the results.

Threats to Validity

It is necessary validation for threats to validate results. According to [33, 34], four main types of validity were conducted as below:

Internal Validity: The internal validity threats are related to the procedures and experiences of participants. In this analysis, people involved in studies came from different levels. That influenced the result. Another threat relates to case studies, the chosen cases came from different regions. Although this can help to generate the generic method for common cases, it also has been a threat to solve.

Construct Validity: The sources of author's research materials general came from trustable or certificated originations, such as IEEE, ACM digital library, etc. in order to minimize this threat. However, some sources still have a low level risk. This may mislead author's analysis direction.

Conclusion Validity: The conclusion was made with literature review, comparisons, interview and case studies.

External Validity: External validity is related to generalize analysis results with whole population. To degrade this threat, literatures and cases were selected from different fields in author's research. At the same time, the research goal is to generate improvements for the Service Department. So the part of this threat is minimized.

ANNEX 9. LIST OF ABBREVIATIONS

ANOVA Statistics: analysis of variance
ACM Association for Computer Machinery

CEO Chief Executive Officer
CSS Customer Service System
CTQ Critical-to-Quality

DMADV Define Measure Analysis Design Verify
DMAIC Define, Measure, Analysis, Improvement and Control
DMEDI Define, Measure, Explore, Develop, Implement
DOE Design of Experiments

ERP Enterprise Resource Planning

FEMA Failure, Effect and Mode Analysis

IDOV Identify, Design, Optimize and Verify
IEEE Institute of Electrical and Electronics Engineers
IM Incident Management
IT Information Technology
ITIL Information Technology Infrastructure Library

JIT Just-in-Time method

LSS Lean Six Sigma

MSA Measurement Systems Analysis
MTBF Mean Time Between Failure

QFD Quality Function Deployment

RPM Resource Planning Management

SIPOC Suppliers, Inputs, Processes, Outputs, and Customers
SLA Service Level Agreement
SPC Statistical Process Control

VOC Voice of the Customer
VSM Value Stream Map