國立交通大學

工業工程與管理學系

博士論文

整合精實與六標準差方法論於服務品質之改善與創新設計

Integrating Lean and Six Sigma Methodologies for Service Quality Improvement and Innovative Design

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摘　要

在今日蓬勃發展的服務業經濟時代裡，提供顧客高品質與快速的服務已經廣泛地被許多世界級的公司視為達成卓越企業績效的重要方法。然而，以快速方式提供高品質服務給顧客的能力，和是否具備良好的服務流程設計有密切的關連。因此，本研究的目標是基於下列兩個觀點，以發展能夠快速提供高品質服務的服務流程的方法；其中一個觀點是關於如何改善現有的服務流程，而另外一個觀點則是和設計或重新設計新的服務流程有關。

首先，針對改善服務流程這個目的而言，本研究探討了兩種當代最新發展的品質方法，亦即精實生產(Lean Production，簡稱 Lean)與六標準差(Six Sigma)方法，並且將其整合應用以發展精實六標準差方法論。整合當前品質管理領域中這兩種最熱門方法的理由，是基於能夠從這兩種方法的個別執行結果中獲得互補性質的效益。另外，在設計與重新設計新的服務流程這一方面，本研究提出一個整合精實與六標準差設計(Design for Six Sigma)方法所發展出來的方法論。類似前述結合精實與六標準差方法的策略，整合應用後者這兩種方法的理由也將被說明。

最後，藉由三個實務案例的導入說明，以檢驗本研究所發展出來的這兩種整合式方法論在服務業應用方面的功效。這些案例當中，其中兩個案例是和執行精實六標準差方法論有關，另外一個案例則是有關精實六標準差設計方法論的執行。從這些實務案例導入後的效益中，可彰顯本研究所提出這兩種方法論所具有的效力，同時因此我們相信這些整合性的方法論可適用於服務業的服務流程改善或設計的任務。

關鍵詞：服務；精實方法; 六標準差方法; 六標準差設計方法。

Abstract

In today's booming service economy, providing customers with high-quality and quick services has been widely recognized by many world-class organizations as an essential means of achieving business excellence. Moreover, the capability of delivering excellent service quality in a fast time-to-market manner is directly tied to a superior service process for the service delivery. Therefore, this doctoral research aims at developing strategies for obtaining the service processes which are capable of fast delivering higher level of service quality based on two different perspectives. One perspective is about how to improve the existing service processes, and the other one is to deal with the issues of new service process design and/or redesign.

Firstly, for the purpose of service process improvement, two state-of-the-art quality approaches, Lean Production (Lean) and Six Sigma were investigated and applied together to developing a Lean Six Sigma methodology. The rationale for the combination of these two popular initiatives in the modern quality management field is based on the complementary benefits obtained from implementing Lean and Six Sigma methodologies individually. On the other hand, to serve the need for designing and/or redesigning new service processes, an integrated methodology was developed by combining Lean with Design for Six Sigma. Similarly to the Lean Six Sigma strategy, an argument for the combined approach was also demonstrated.

Finally, three empirical case studies were conducted to examine the efficacy of these integrated methodologies for their applications to service in particular. Among them, two cases were for the implementation of the Lean Six Sigma methodology, and the other one was then for the application of the Design for Lean Six Sigma methodology. The achievement obtained from implementing these project cases have highlighted the good capabilities of the methodologies proposed in this research, and therefore it is believed that they can be applied to the service field for performing the tasks of process improvement and/or new process design.

Keywords: service; Lean; Six Sigma; Design for Six Sigma.

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1. Introduction

1.1 Research background

Services have experienced significant growth over the past decades; they now represent a major portion of the economies of the world's more industrialized nations. Even in lesser-developed countries, the service sector still accounts for a substantial part of their economies (Davis and Heineke, 2003). In addition, the service industries not only have grown in size, but along the way they also have absorbed all the jobs shed by traditional industries such as agriculture, mining, and manufacturing. For instance, by the mid-1990s, the service industries employed nearly 80 percent of the workforce in the United States (Hoffman and Bateson, 2002).

Today, in service applications, the revenue growth potential of improving the speed of and quality of service often overshadows the cost reduction opportunities. However, service processes are typically slow processes, because there is far too much waste such that the costs of services are inflated and service quality deteriorates. Moreover, one of the characteristics of service proposed by Zeithaml et al. (1985) is the heterogeneity, which means the occurrence of variations in the level of service to customers, and it consequently results in poor service quality and customers' dissatisfaction. These service issues represent a huge opportunity to improve the service quality by increasing the speed of service delivery and reducing the variations in service level.

Meanwhile, according to Ramaswamy (1996), excellent service quality can be achieved by developing a superior service process design. This means that a well-designed service process is necessary for delivering higher level of service quality. In addition, as highlighted in literature, at least 80 percent of the service quality is committed in the early design phases of the process life cycle (Yang and El-Haik, 2003), and up to 80 percent of the total cost of the service is accrued in the concept development stage of these upfront phases (Fredriksson, 1994). Such research results have motivated recent attention given by various fields to shift from improving the service performance during the later phases of the process life cycle to the front-end design phases where the service was initially developed.

In recent years, Lean and Six Sigma disciplines have been popularized because their successful implementations by many world-class organizations around the world to improve business processes and reap substantial benefits of cost savings. On the other hand, to deliver a higher quality level of service than the rival, Design for Six Sigma (DFSS) works on the early stages of the process life cycle and utilizes the most powerful tools and methods presently known for developing optimized service designs. The major objective of DFSS, when applied to the service field, is to design the service right the first time to avoid painful and costly downstream experiences.

Finally, it was found in a literature study that although it is possible to have independent successes in Lean, Six Sigma, and DFSS, each magnifies the strengths of the other while compensating for the weaknesses when integrated in an overall improvement or design strategy. Therefore, it is the motivation for this research that blending the strengths of Lean and Six Sigma can be synergistic in the context of service process improvement, while the combination of Lean and DFSS can achieve the goal of providing excellent service process designs.

1.2 Research objectives

The primary objectives of this research can be outlined as follows based on the premise described in Section 1.1. Firstly, it aims at developing a unique strategy for improving the existing service processes through a combined approach of Lean and Six Sigma. Next, the focus is placed on the design and/or redesign of new service processes by fusing the powers of Lean and DFSS to develop a Design for Lean Six Sigma methodology. Finally, to demonstrate the efficacy and effectiveness of the two integrated systems, several empirical case studies in the service field are conducted.

Furthermore, a clear rationale for the integration of either Lean with Six Sigma or Lean with DFSS must be provided to justify these combined approaches. First of all, the reason for why we adopted Lean, Six Sigma, and DFSS instead of other quality methods mostly lie on the facts of the successful implementation of each discipline by numerous world-class organizations over the recent past decade. Moreover, the well-proven and previously known principles, methods, and tools used by these methodologies make the deployment strategies we developed more easily to understand and implement. The next level of the question is why we used a combined but not individual approach. The answers to this question have to be clarified and understood before we go into details for the development of an integrated system.

Lastly, one issue also need to be addressed is to explain why these integrated strategies are applicable for the service settings particularly. To work out this issue, we have to start form understanding the basics of the service, and establish a correlation between the service essentials and the strategies we intend to develop. Only after achieving this, then it would be appropriate to position these integrated approaches as being service-oriented. The final task to be done is to prove their capabilities through practical case studies in the service field.

1.3 Research framework

Prior to starting the research work, it is helpful to provide an overview of the research structure for briefly understanding the philosophies and approaches underlying the overall research process. To fill this need, a research framework was constructed as shown in Figure 1.1.

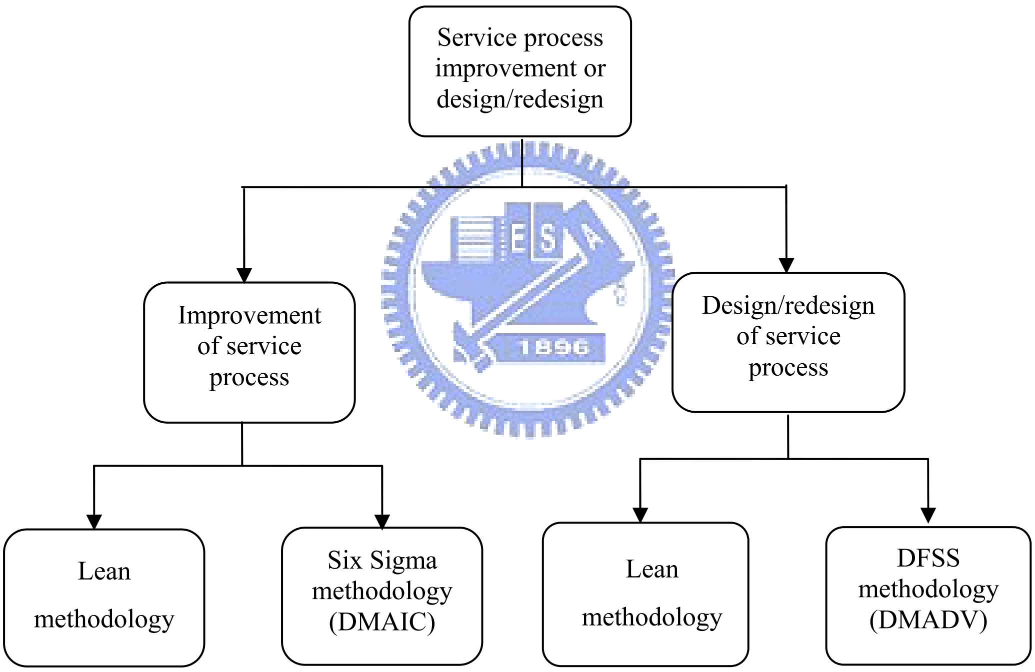

Figure 1.1 A research framework

The picture in Figure 1.1 also indicated the methods utilized in the different aspects of this research topic which are service process improvement and design/redesign. For the service process improvement, the five-step methodology of Lean and Six Sigma's well-known DMAIC methodology are applied together; while a selected DFSS methodology, DMADV, is combined with the Lean methodology for their applications to service process design and/or redesign.

The occasions of using DMAIC and DMADV methodologies can be further distinguished and depicted in Figure 1.2. The DMAIC methodology should be used when a process is in existence in an organization but is not meeting customer specifications or is not performing adequately. On the other hand, the DMADV methodology should be used when a process is not existence and one is needed to be developed, or when the existing process exists but still doesn't meet the level of customer specifications.

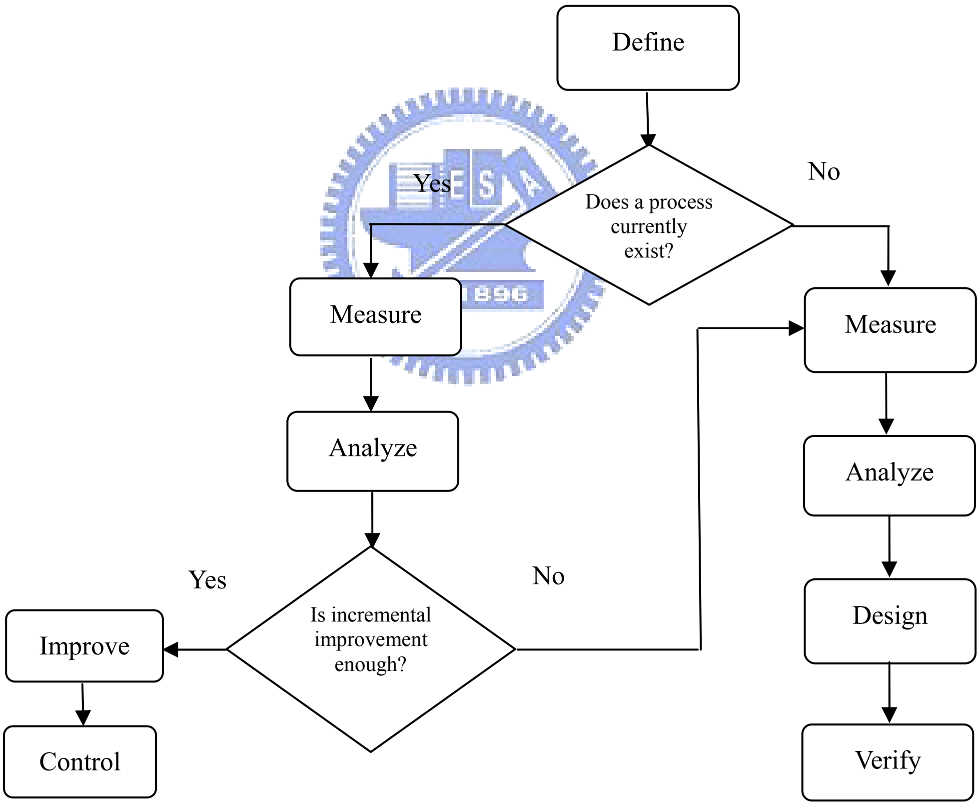

Figure 1.2 The occasions of using DMAIC and DMADV methodologies

2. Literature Review

2.1 Lean

The origination of Lean can be traced back to the late 1980s when John Krafcik, a research assistant at the Massachusetts Institute of Technology with the International Motor Vehicle Program, coined the term Lean Production (Marchwinski, 2004). The concepts and practices of Lean Production was pioneered by Toyota Motors after World War II with the emphasis on making products in wider variety at lower volumes with fewer defects. Initially, the publication of the book, *The Machine that Change the World: the Story of Lean Production* (Womack et al., 1990) started the diffusion of some Lean production practices developed by the most competitive auto manufacturers in the world (Sanchez and Perez, 2001). Thereafter, Lean production was studied in other industries (Moore and Gibbons, 1997). Some scholars have even suggested that rapid change industries have adopted lean production versus mass production as a growth paradigm (Duguay et al., 1997).

The objective of Lean Production is to eliminate all forms of waste (Womack et al., 1996) including:

- Overproduction
- Waiting for machines or operators
- Transportation waste
- Process waste resulting from inefficient, poorly designed processes
- Excessive inventory
- Wasted motions through operators leaving workstations to fetch required suppliers or through continuous reaching, searching, or carrying goods

- Waste of rework through producing defects

Similarly to those waste in the manufacturing environment, typically, there are many waste in the service processes such that services are usually delivered at a slow pace. When all the waste are eliminated, the service order cycle time (time from receipt of order to receipt of payment) is compressed. The result is short cycle and delivery times, higher quality, and lower costs.

Some points of view on Lean including the pros and cons can be found in literature. They were summarized as follows.

- Lean thinking provides a way to make work more satisfying by providing immediate feedback on efforts to convert *muda* into value. And, in striking contrast with the recent craze for process reengineering, it provides a way to create new work rather than simply destroying jobs in the name of efficiency (Womack, 2004).
- The overarching benefit of Lean is the ability to see cost and lead time reduction opportunities where you never saw them before. Through application of the Lean concepts and tools, the process steps once thought essential are unnecessary, and their costs and delays removable after Lean tools have been applied (George, 2003).
- Lean initiatives are great for boosting productivity, changing a culture and cleaning up factories. Lean brings action and intuition to the table and quickly attacks low hanging fruit with kaizen events (Sanchez et al., 2001).
- Since Lean was essentially defined empirically based on the practices in use at Toyota, it provides more principles than specific tools or methods (Hoerl, 2004).
- Lean does not explicitly prescribe the culture and infrastructure needed to achieve and sustain results (George, 2003).

- Lean does not value statistical analysis to reduce variation and bring a process under statistical control (Nave, 2002).

The Lean methodology consists of a five-step thought process which is developed by Womack and Jones (1996) to guide managers through a lean transformation. These steps are:

Step 1: Value

Define value from the perspective of the final customer. Express value in terms of a specific product or service which meets the customer's needs at a definite price and at an explicit point in time.

Step 2: Map

Identify the value stream, the set of all specific actions required to bring a specific product through the three critical management tasks of any business including the problem-solving task, the information management task, and the physical transformation task. Create a map of the current state and the future state of the value stream. Identify and categorize waste in the current state, and eliminate it.

Step 3: Flow

Incorporate the remaining steps to streamline the value stream. Eliminate functional barriers, reduce interruptions, and develop a process-focused organization that dramatically improves lead time.

Step 4: Pull

When flow is introduced, the ability to design, schedule, and make exactly what the customer wants just when the customer wants it, is established. In other words, let the customer pull products on an as needed basis rather than push products, often unwanted, onto the customer.

Step 5: Perfection

There is no end to the process of reducing effort, time, space, cost, or mistakes. Return to the first step and begin the next lean transformation process, offering a product or service which is closer to what the customer really wants.

Many companies were benefited by the implementations of Lean projects. Some successful examples were given as follows.

- Porsche implemented a Lean system in 1993. In the finally assembly area, the space for inventories were reduced from 40 percent to zero, the amount of parts on hand was reduced from 28 days to essentially zero, and parts were held to in the assembly area for about twenty minutes before the completed engine was sent to the final assembly area (Womack and Jones, 1996).
- At Credence Systems, a leading global supplier of automatic test equipment, a work team doubled the output through a bottleneck circuit-card testing work center within six weeks using Lean techniques (Devane, 2004).
- At Pratt's North Haven, Connecticut, turbine airfoil facility, a Lean program caused overdue parts to fall from $80 million to zero, inventory was cut in half, the manufacturing cost of many parts was cut in half, and labor productivity nearly doubled (Womack and Jones, 1996).

2.2 Six Sigma

Six Sigma was first espoused by Motorola in 1985 when the late Bill Smith, a senior engineer and scientist, came up with the idea of inserting hard-nosed statistics into the blurred philosophy of quality. The result was a culture of quality that permeated Motorola and led to a period of unprecedented growth and sales. The crowning achievement was being recognized with the Malcolm Baldrige National

Quality Award in 1988 (Breyfogle et al., 2001). Although invented at Motorola, Six Sigma has been experimented with by Allied Signal and Perfected at General Electric (GE). The successful implementation of Six Sigma by GE, which has obtained huge cost savings, induced the fervor of pursuing Six Sigma around the world since it afterwards. Six Sigma is now also extensively applied to non-manufacturing processes. The savings from transactional, support, service and other non-manufacturing sectors are significant (Reichfield and Sasser, 1990).

Six Sigma is a methodology that provides business with the tools to improve the capability of their business processes. For Six Sigma, a process is the basic unit for improvement. A process could be a product or a service process that a company provides to outside customers, or it could be an internal process within the company, such as billing or production process. In Six Sigma, the purpose of process improvement is to increase performance and decrease performance variation. This increase in performance and decrease in performance variation will lead to defect reduction and improvement in profits, to employee morale and quality of product, and eventually to business excellence (Yang and El-Haik, 2003).

Recently, there are numerous prominent researchers who have expressed their points of view on Six Sigma in literature, and we extracted some of them as follows.

- Six Sigma is a comprehensive and flexible system for achieving, sustaining, and maximizing business success. It is driven by close understanding of customers' needs and disciplined use of facts, data, and statistical analysis (Pande, Neuman and Cavanach, 2000).
- The Six Sigma breakthrough strategy is a system that provides managerial, statistical, and problem-solving methods that enable a company to achieve step function (breakthrough) improvement capabilities (McAdam and Evans, 2004).

- Six Sigma is a highly disciplined process that helps organizations to focus on developing and delivering near-perfect products and services. It is also a change-acceleration process that focuses on pursuing success and the rapid adoption of change (Smith., 2001).
- Strategically, Six Sigma can be defined as a business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet customers' needs and expectations (Harry et al., 2000).
- Six Sigma's limitations are inherent in its nature as a project-oriented, problem-solving regimen. Six Sigma assumes that the existing process design is fundamentally sound and just needs minor adjustments to be more efficient. That assumption is not the road to dramatic improvement. (Hammer, 2002)
- Daily management is not emphasized and there is no concept of total participation in Six Sigma. Without the cooperation of the existing organization at the implementation stage, achieving high levels of customer satisfaction could be difficult under Six Sigma (Su et al., 2003).
- Six Sigma cannot dramatically improve process speed or reduce invested capital (George, 2003).
- Six Sigma does not consider system interaction because processes are improved independently (Nave, 2001).

Overall, Six Sigma is a top-down approach that is led by the company Chief Executive Officer, and the roles of the Champion, Master Black Belt, Black Belt, and Green Belt usually organize the infrastructure of a Six Sigma project. The Six Sigma methodology that is most widely used is known as DMAIC (Define, Measure, Analyze, Improve and Control). DMAIC offers a structured and disciplined methodology for solving business problems and enables a business to achieve extremely low non-conformance rates (Harry and Schroeder, 2000). The Six Sigma tool kit includes a variety of techniques, primarily from statistical data analysis and quality improvement. Many tools are familiar from the era of total quality management; others are more recent and sophisticated (Breyfogle, 1999). New tools will continue to be selectively added from other disciplines, for example, the field of operations research (Hoerl, 2004). A depiction of the purpose, deliverables, and key tools of each step in the DMAIC process are shown in Figure 2.1 (Snee, 2004).

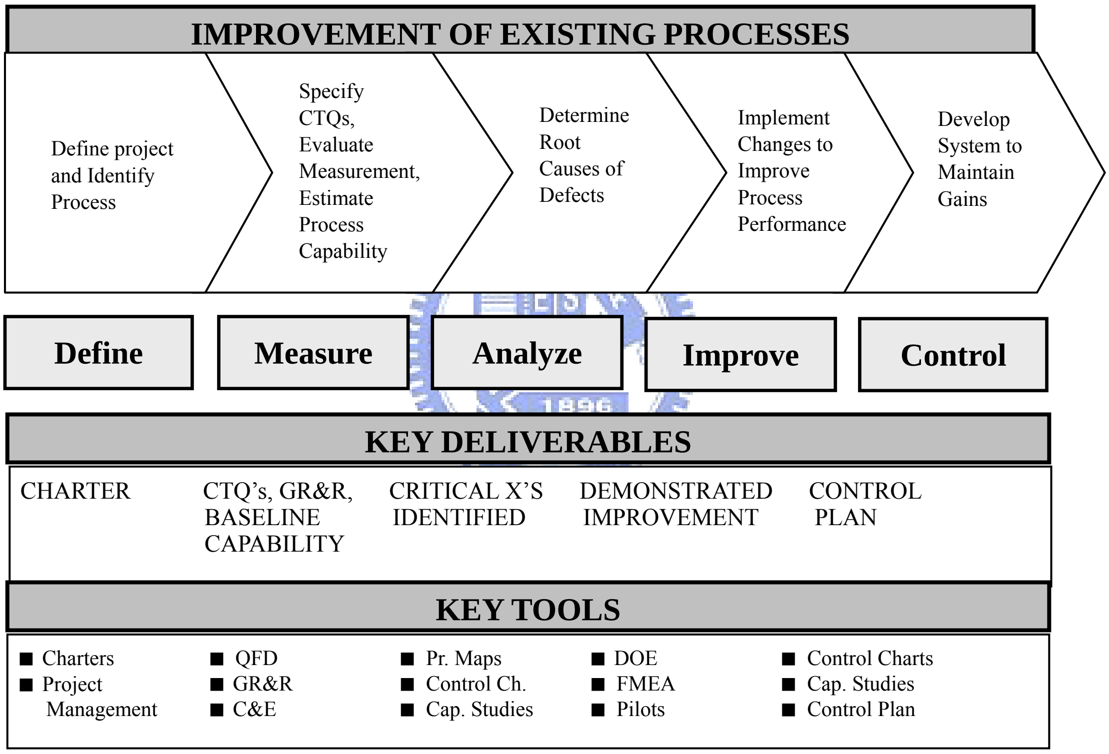

Figure 2.1 The DMAIC methodology and key tools

Six Sigma success stories abound in a variety of industries. In addition to the well-known achievement of Six Sigma programs at General Electric (GE), the following represent additional examples of the successful Six Sigma implementations.

- Six Sigma enabled AlliedSignal to avoid having to build an $85 million plant to fill increasing caperolactan demand, realizing a total savings of $30 to $50 million a year (Harry et al., 2000).

- Lockheed Martin used to spend an average of two hundred work hours fitting a part that covers the landing gear. For years employees had brainstorming sessions that resulted in many seemingly logical solutions. However, none worked. The statistical discipline of Six Sigma discovered a one-thousandth of an inch deviation in the part that caused the problem. Now that it has been corrected, the company saves $14,000 a jet (Devane, 2004).
- Ford Motor's 2000 annual report: "In the past year we launched Customer Driven 6-Sigma, a scientific, data-driven process to uncover the root cause of customer concerns and drive defects … saving the company $52 million." (Gupta, 2004)

2.3 Design for Six Sigma

Since the inception of Six Sigma at Motorola, many leading companies such as General Electric have consummated operational excellence through their successful Six Sigma project implementation. However, its incremental improvements alone sometimes do not allow an organization to keep up with the rapid pace of changes in the areas of technology, customer demands, and competition (Pande et al., 2000). That is why DFSS has treaded in Six Sigma's steps as a breakthrough strategy for developing high-quality products and/or services.

DFSS is a rigorous approach to designing products and/or services from the very beginning of the development cycle to ensure that meet customer expectations (Harry and Schroeder, 2000). As a complement to Six Sigma's improvement methodology, DFSS integrates the characteristics of Six Sigma at the outset of the product and/or service development process with a disciplined set of tools to achieve Six Sigma performance (Brue and Launsby, 2003). However, unlike the DMAIC methodology of Six Sigma, the phases or steps of DFSS are not universally recognized or defined. In fact, many deploying companies of the Six Sigma philosophy have devised their in-house views of DFSS such that there are different labels of acronyms of DFSS methodology as shown in Table 2.1 (Simon, 2002). The best strategy an organization can take is to understand the critical elements contained within each version of DFSS methodology, and then customize it to fit the organizational culture (Verduyn, 2002).

Table 2.1 Some different versions of DFSS methodology

Methodology	Definition
DMADV	Define, Measure, Analyze, Design, Verify
DMADOV	Define, Measure, Analyze, Design, Optimize, Verify
IDOV	Identify, Design, Optimize, Validate
ICOV	Identify, Characterize, Optimize, Verify
DMEDI	Define, Measure, Explore, Develop, Implement
DCCDI	Define, Customer, Concept, Design, Implement

Despite the different versions of DFSS methodology, each one basically uses the same advanced design and production development tools and generates the same deliverables in the underlying phases (Kleinert, 2004). In this paper, DMADV is selected as the fundamental structure to develop an integrated methodology for service process design and/or redesign. The reason for this selection is that DMADV has been a proven and well-established DFSS methodology used among many industries. The framework of DMADV methodology is further depicted in Figure 2.2

(Anonymous[a], 2005).

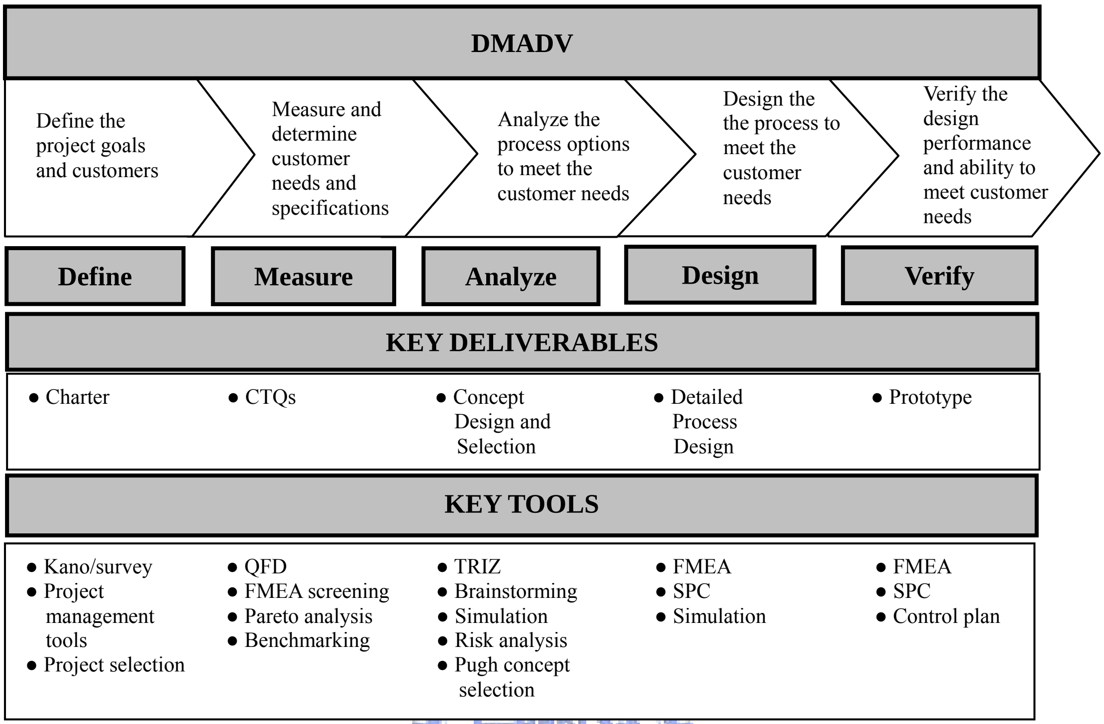

Figure 2.2 The framework of DMADV methodology

2.4 The rationale for combining Lean with Six Sigma

To demonstrate the rationale for the synthesis of Lean and Six Sigma, it was noted in the literature that despite having the potential of reaping individual benefits from the two methodologies, some challenges were also highlighted for Lean and Six Sigma respectively. By examining Table 2.2, which was based on a literature research of publications by McAdam and Evans (2004), George (2003), and Nave (2002), there are some complementary and commonality results obtained by comparing both Lean and Six Sigma approaches. The complementary results emphasized that Six Sigma focuses on reducing process variation and enhancing process control, while Lean drives out waste and promotes work standardization and flow. Nevertheless, because process improvement requires key aspects of both approaches to drive positive results, they can be reasonably integrated.

Table 2.2 The benefits and challenges for Six Sigma and Lean

Methodology	**Six Sigma**	**Lean**
Benefits	Uniform process output	Cycle time reduction
	Defect reduction	Work-in-process reduction
	Cost reduction	Cost reduction
	Productivity improvement	Productivity improvement
	Culture change	Shorten delivery time
	Customer satisfaction	Space saving
	Market share growth	Less equipment needed
	Product/service development	Less human effort
Challenges	System interaction is not considered because processes are improved independently	Statistical or system analysis not valued
	Lack of specific speed tool	Process incapability and instability
	Long project duration	People issues

In addition, it is also useful to provide some likely reasons why either Six Sigma or Lean alone may fail to achieve absolute perfection to illustrate why the combination is to prove superior. According to the findings in the research paper by Arnheiter and Maleyeff (2005), some organizations that have embraced either Lean or Six Sigma discovered that they eventually reach a point of diminishing returns. That is, after re-engineering their operating and supporting processes, further improvements are not easily generated. An analysis of such research findings was summarized in Figure 2.3 and depicted in more detail as follows.

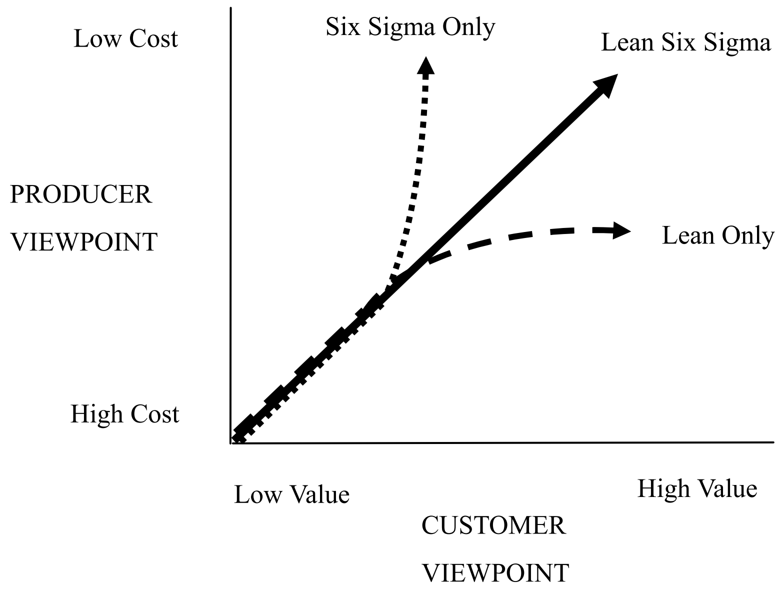

Figure 2.3 The nature of improvements that may occur in organizations that practice Lean, Six Sigma, or Lean Six Sigma (Arnheiter and Maleyeff , 2005)

The horizontal axis in Figure 2.3 represents the customer's perspective of value, including quality and delivery performance. The vertical axis represents the producer's cost to provide the product or service to the customer. Under either system, improvements will be made, but these improvements will begin to level off at a certain point of time. With Six Sigma alone, the leveling off of improvements may be due to the emphasis on optimizing measurable quality and delivery metrics, but at the same time, ignoring changes in the basic operating systems to remove wasteful activities. With Lean alone, the leveling off of the improvements may be due to the emphasis on streamlining product flow, but doing so in a less than scientific manner in the use of data and statistical quality control methods.

Other cases in the literature which supported adopting the Lean Six Sigma strategy for process improvement were obtained from a survey of recent publications. For example, BellSouth Corporation developed a management method which includes the critical elements of Lean and Six Sigma to achieve both operations and process excellence (Dunphy and Lewis, 2006); Ward (2006) presented a case study which a company that produces injection molded plastic containers for cosmetic industry had shortened production time and reduced raw material costs by adding the Six Sigma approach to a Lean project; Brett and Queen (2005) proposed a strategy which applied the combined approach to improving an enterprise records management process.

2.5 The rationale for combining Lean with Design for Six Sigma

To demonstrate the rationale in favor of the combination of Lean and DFSS, Smith (2001) offered a more comprehensive view on this subject through the framework as shown in Figure 2.4. He attempted to locate each discipline in a two-dimensional array, one related to Suh's (1990) model for domains of designs, and the other one related to reality perception according to Senge's (1990) model of Systemic Thinking. The Suh's model emphasizes a mapping between various domains from customer attributes to functional requirements to design parameters to process variables. On the other hand, the Senge's model distinguishes the levels of thinking in terms of events, patterns, or structure.

By examining the combined model, it helps justify the appropriateness of integrating Lean and DFSS for designing new services. First, compared with Six Sigma's focus on problem solving at the event level of thinking, DFSS is used to prevent problems by building quality into the design or redesign process across domains at the pattern level of thinking. Since up to 80 percent of the total cost of the product and/or service is accrued in the upfront design phases (Fredriksson, 1994), more and more organizations have their focus transitions from Six Sigma to DFSS.

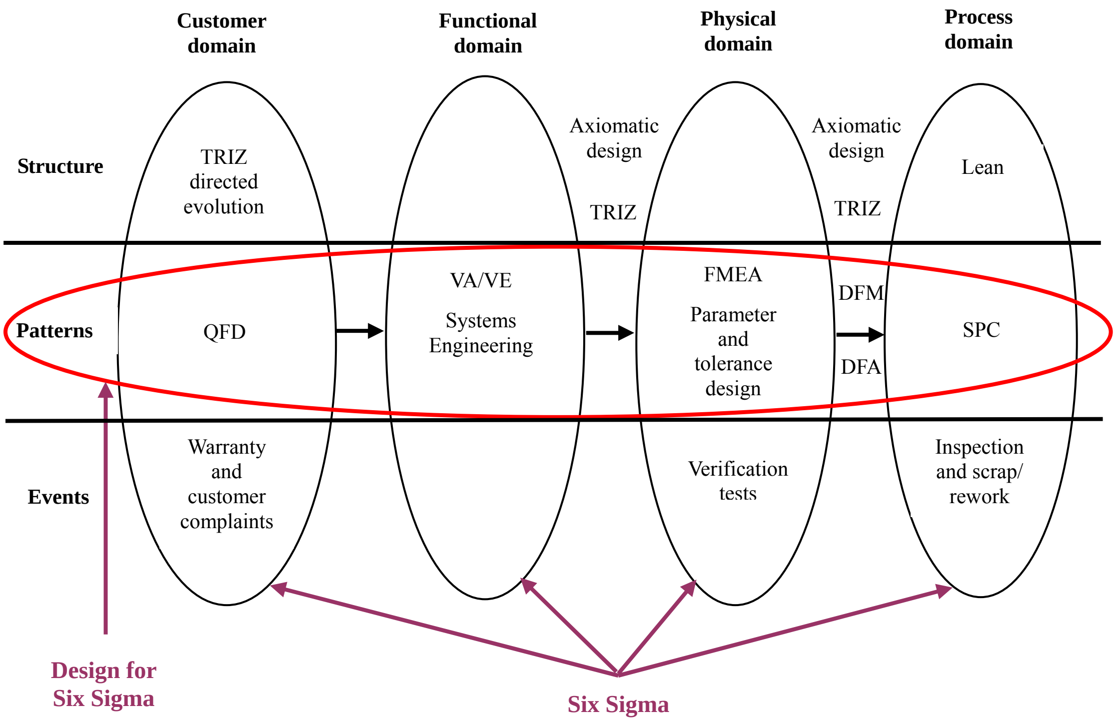

Figure 2.4 A comprehensive view on the combination of Lean and DFSS (Smith, 2001)

Next, Lean is identified at the structure level in Senge's model. Thinking at a level of fundamental structure offers even higher leveraged opportunities to create products and/or services that not only function as intended, but also deliver unprecedented customer satisfaction. When the foundational structure of design is properly established, the methods at the pattern level are much more effective. When pattern level methods work well, the event outcomes become world-class (Smith, 2001).

2.6 Measurement of service quality

It is necessary to define how to measure the service quality prior to the development of an integrated methodology for service process design and/or redesign, which has a direct impact on the delivery of service quality to the customer. A set of service quality dimensions that is widely cited has been compiled by Parasuraman et al. (1988), and constitutes the basis for measuring the level of service quality. These dimensions of service quality are described as follows (Kurtz and Clow, 1998).

- *The tangibles dimension*: tangibles focus on the service provider's physical facilities, their equipment, the appearance of employees, and communication materials.
- *The reliability dimension*: reliability reflects the ability of the service firm to perform the service as promised consistently and dependably.
- *The responsiveness dimension*: responsiveness refers to the willingness of the firm's staff to help customers and to provide them with prompt service.
- *The assurance dimension*: assurance addresses the knowledge and courtesy of the company's employees and their ability to inspire trust and confidence in the customer toward the service provider.
- *The empathy dimension*: empathy is the service firm's ability to care and experience another's feeling as one's own.

3. Developing Integrated Methodologies

Now that the rationale for the combinations of both Lean with Six Sigma and Lean with DFSS has been demonstrated in Subsections 2.4 and 2.5, therefore this section will develop an integrated methodology for each purpose of the service process improvement and design and/or redesign respectively.

3.1 Developing a Lean Six Sigma methodology for service process improvement

Using the well-proven DMAIC technique of Six Sigma and the five-step procedure of Lean, a conceptual framework for the Lean Six Sigma methodology is developed as shown in Figure 3.1, and each step in the methodology is described in turn as follows

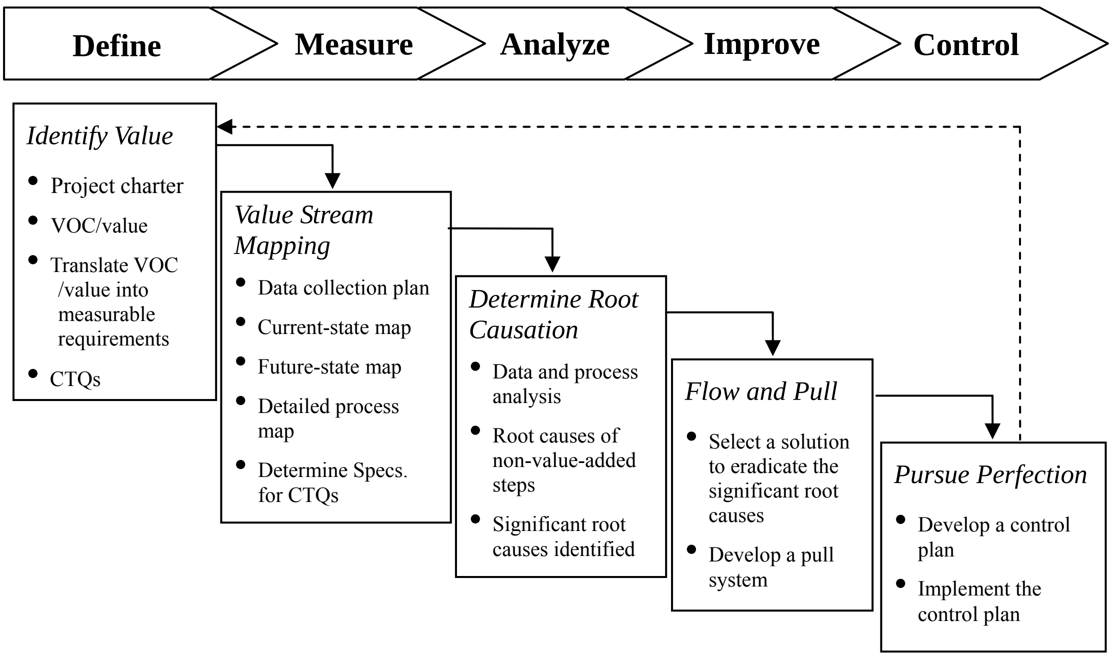

Figure 3.1 A conceptual framework of the Lean Six Sigma methodology

Phase 1: Define/identify value

Step 1: Draft a project charter.

The primary deliverables in the establishment of a project charter include the following items (Pyzdek, 2003):

- business case
- project goals and objectives
- milestones
- project scope, constraints, and assumptions
- team memberships
- roles and responsibilities
- preliminary project plan.

Step 2: Identify the voices of the customers (VOCs)/the customer values.

In this step, both the external customer and the internal employee are fully identified, and their needs are collected and analyzed.

Step 3: Translate the VOCs into measurable requirements.

Because the VOCs could be disorganized, nonspecific, or qualitative in nature, therefore, each of them needs to be translated into a measurable requirement. This task can be accomplished by using the quality function deployment (QFD) tool (Mizuno and Akao, 1994).

Step 4: Identify the critical-to-quality characteristics (CTQs).

Among the measurable requirements, identify the CTQs, which represent the relatively important ones to service quality based on the perspectives of both customers and employees.

Phase 2: Measure/value stream mapping

Step 1: Create a data-collection plan and gather data.

Before the start of data collection, a data-collection plan is developed to determine such issues as sampling frequency, the measuring instruments and the format of data-collection form. Then, collect data in order to measure the CTQs, which are under observation.

Step 2: Construct a current-state value stream map.

A current-state value stream map shows work processes as they currently exist. This is vital both to understand the need for change and to understand where opportunities exist.

Step 3: Construct a future-state value stream map.

A future-state value stream map deploys the opportunities for improvement identified in the current-state map to achieve a higher level of performance.

Step 4: Develop a detailed process map.

Some limitations exist in value stream mapping. For example, it does not begin to capture all specific actions, and it is a technical tool which lacks the capability to address non-technical and/or human issues (Anonymous[b], 2004).

Step 5: Determine the specification levels for CTQs.

This step is to set the goals for achieving the desired or acceptable levels of service quality for both customers and employees.

Phase 3: Analyze/determine root causation

Step 1: Conduct data and process analysis.

Examine the data collected and the detailed process maps to characterize the nature and extent of the defects occurring in the service delivery process.

Step 2: Identify root causes of non-value-added steps.

Identify and validate the root causes of why the defects occur in the non-value-added steps.

Step 3: Determine the significant root causes.

Among the root causes identified, the significant ones are determined and given a first priority of being removed from the service processes.

Phase 4: Improve/flow and pull

Step 1: Eliminate the significant root causes.

Select a solution to eradicate the significant root causes that have the most impact on the CTQs.

Step 2: Develop a pull system.

A pull system means the customer pulls the products and/or services on an as needed basis rather than push them onto the customer. A specific sequence for creating a pull system was suggested by George (2003).

1. Identify/confirm the service level we want to achieve, i.e., ask our customers what service level they expect.
2. Determine our work group's completion rate based on data.

3. Determine maximum work-in-process by using Little's law (Little, 1961).
4. Cap the active work in the process at the maximum work-in-process.
5. Put all incoming work into an input buffer.
6. Develop a triage system for determining which incoming work should be released into the process next.
7. Continue with other process improvements so we can improve completion rate and further reduce lead time.

Phase 5: Control/pursue perfection

Step 1: Develop a control plan.

A control plan is developed to make sure the solutions endure, and control must occur at both the strategic and tactical levels. The typical use of a control chart, run chart (R-chart), or check list can serve this purpose (Gupta, 2004).

Step 2: Implement the control plan.

To facilitate the implementation of the control plan, a few suggestions were made as follows (De Feo and Barnard, 2004).

- Transfer to the operating functions all the updated control plans, etc., and train the people involved in the process in the new procedure.
- Audit the process as well as the new controls periodically to assure the gains are maintained.
- Transfer the audit function to the operating forces after a suitable period of time, and disband the team with appropriate recognition.

3.2 Developing a Design for Lean Six Sigma methodology for service process design and/or redesign

As it was mentioned in Subsection 2.5, the version of DMADV methodology was adopted as a DFSS strategy for its combination with Lean to develop an integrated approach. A conceptual framework of the Design for Lean Six Sigma methodology is delineated in Figure 3.2 as follows.

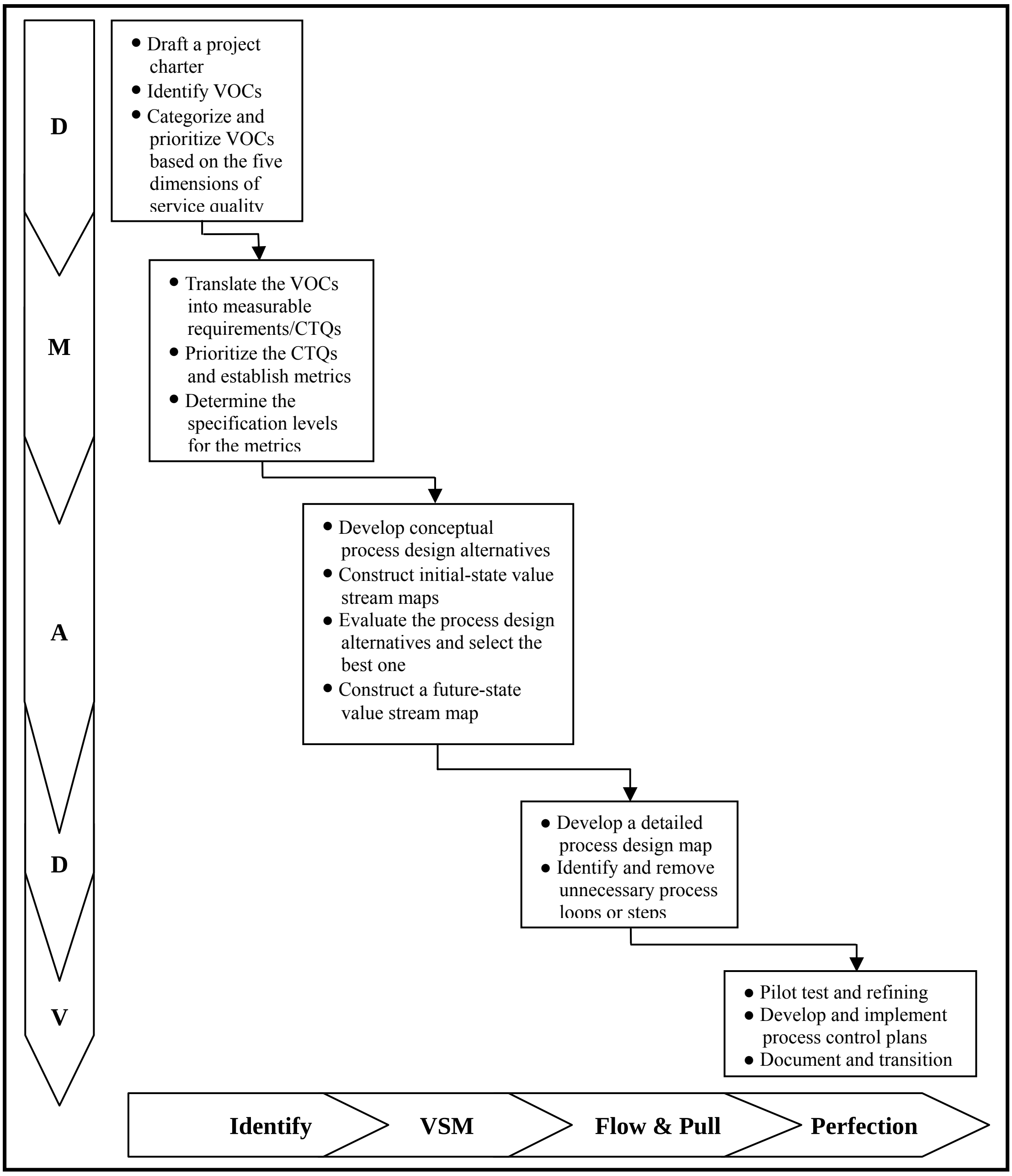

Figure 3.2 A conceptual framework of the Design for Lean Six Sigma methodology

Next, the descriptions of each step in the methodology are given in further detail as follows

Phase I: Define

Step 1: Draft a project charter.

The primary deliverables in the establishment of a project charter include the following items (Pyzdek, 2003):

- Business case
- Project goals and objectives
- Milestones
- Project scope, constraints, and assumptions
- Team memberships
- Roles and responsibilities
- Preliminary project plan

Step 2: Identify the voices of the customer (VOCs).

In this step, both external and internal customers are fully identified, and their needs that are valued by either of them are collected and analyzed. Some commonly used tools such as surveys, focus groups, interviews, or market research can be exploited to perform this task (Pande et al., 2000).

Step 3: Categorize and prioritize the VOCs based on the five dimensions of service quality.

First, examine and screen the identified VOCs based on the five service quality dimensions. If there is any VOC that falls beyond the scope of the five dimensions, then it is set aside for managers to consider for additional action. Next, the prioritization of the VOCs can be obtained according to customer’s evaluation.

Phase II: Measure

Step 1: Translate the VOCs into measurable requirements/critical-to-quality characteristics (CTQs).

Each of the screened and prioritized VOCs is translated into a measurable requirement because the VOCs could be disorganized, nonspecific, or qualitative in nature. In addition, all of the translated measurable requirements then become the CTQs that must be satisfied by the design solution. Using the quality function deployment (QFD) method (Mizuno and Akao, 1994), this transformation of the critical customer needs into measurable terms/CTQs can be accomplished.

Step 2: Prioritize the CTQs and establish performance metrics.

The CTQs identified in the last step are further prioritized through the employment of QFD again. Then, applying Pareto analysis (Juran, 1979), the performance metrics are established to measure the performance of the new process design.

Step 3: Determine the specification levels for the performance metrics.

This step is to set the goals for achieving the desired or acceptable levels of the design performance for both customers and employees. The task can be performed along with conducting surveys among the customers and employees, or using benchmarking and competitive analysis within the industry.

Phase III: Analyze

Step 1: Develop conceptual process design alternatives.

Based on the performance metrics established earlier, this step proceeds to generate several conceptual process design options that can deliver the design requirements of the performance metrics. For this purpose, TRIZ technique (Altshuller, 2004) can be applied to creating innovative design concepts particularly when the existing technology or the known process design cannot fulfill all the design requirements satisfactorily.

Step 2: Construct an initial-state value stream map for each process design alternative.

An initial-state value stream map is utilized to identify the non-value-added activities in the process design alternatives that need to be eliminated, if unnecessary, and to present the opportunities for improvement. By taking advantage of the Lean principles, the non-value-added process activities can be identified and eliminated.

Step 3: Evaluate the process design alternatives and select the best one.

Several process design alternatives and initial-state value stream maps might be generated in the last two steps, and they need to be evaluated to make a final determination on which process design concept will be selected.

Step 4: Construct a future-state value stream map for the selected process design alternative.

A future-state value stream map exploits the opportunities for improvement identified in the initial-state map to achieve a higher level of performance. This means once the unnecessary non-value-added activities are eliminated, the remaining activities can be re-sequenced to further enhance the value delivery by the new process flow.

Phase IV: Design

Step 1: Develop a detailed process design map.

Some limitations exist in value stream mapping (VSM) process (Anonymous[b], 2004). For example, VSM does not begin to capture all specific actions, and it is a technical tool that lacks the capability to address non-technical and/or human issues. On the other hand, a detailed process design map can help identify the unnecessary loops or steps in the overall process design which may not be discovered in the value stream maps.

Step 2: Identify and remove the unnecessary loops or steps in the detailed process design map.

Identify the unnecessary process loops or steps in the detailed process design map, if any, and then remove them from the overall process design in order to eliminate the *waste* in Lean terminology.

Phase V: Verify

Step 1: Conduct pilot test and refining.

Prior to launching the new service process design, a pilot and small-scale implementations can be used to test and evaluate real-life performance.

Step 2: Develop and implement control plans.

Control plans need to be developed and implemented to make sure the new process design endures, and control must occur at both the strategic and tactical levels.

Step 3: Document and transition.

As the new process design is validated and process control is established, the full-scale commercial rollout can be started, and the new design, together with the supporting processes, can be handed over to design and process owners, complete with requirement settings, and control and monitoring systems.

4. Empirical Case Studies

In the following subsections of 4.1 through 4.3, three practical case studies were conducted after the integrated methodologies in Section 3 were developed. The purpose for the case studies is to examine the efficacy and effectiveness of the methodologies in their applications to the service field in particular.

4.1 Case: patent filing service

4.1.1 The background of the case

The specific case we focused on is a firm which primarily provides patent filing services for its customer base which is largely in the manufacturing sector in Taiwan. Too often, the firm receives complaints from their customers that the patent filing time interval is usually longer than they expected. With the issue of extra patent filing time needed, the completion date of the patent filing schedule is delayed and a patent rework process needs to be instituted in response to the official requirements by the government. Consequently, this would impact the chance of getting a patent approval and achieving the corporate objective to be among the top ten patent filing service providers in the nation in terms of the annual total number of patents approved. Moreover, when it is possible, customers prefer a stable and consistent schedule for the completion of a patent filing process. Lastly, according to a survey conducted among customers and employees of the patent service firm, the patent engineers in the firm often spent too much time on the processes of correcting technical specifications, writing disclosure documents, and searching reports. This has become a major bottleneck problem in the whole process of the patent filing services.

To resolve these problems, therefore, the company had implemented an improvement project through the use of the Lean Six Sigma methodology as developed in this research. The details for implementing the methodology are described step-by-step as follows.

4.1.2 Implementing the Lean Six Sigma methodology

Phase 1: Define/identify value

Step 1: Firstly, a project team was established with, in total, six members from patent engineering, legal, finance, and administration, and a project charter was developed at the outset of the project implementation. In the charter, two project goals had been set as follows.

- To achieve an average process cycle time of 75 days and a standard deviation of 3 days;
- To achieve a total cost savings of US$100,170 which includes the hard savings of US$76,610 and the soft savings of US$23,560.

Step 2: Two surveys were conducted among the external customers and the firm's employees. Of the 600 external customers sampled, 152 usable responses were received. In addition, an e-mail questionnaire was sent to the 82 patent-related personnel within the firm, and 73 usable responses were collected. Tables 4.1 and 4.2 summarized the VOC results obtained from the external and internal surveys.

Table 4.1 Summary of the VOCs in the external customer survey for the patent filing service

VOCs	Frequency*	Percentage
Shorter patent filing interval	142	93
Stable and consistent schedule for process completion	126	83
Regular progress update report	98	64
Detailed suggestions in customer reports	89	59
Risk analysis report	58	38
Contingency plans for the patent rework process	52	34
Others	44	29

* The frequency was accumulated by counting the number of those responses which gave the priority level of at least 4 to each specific item in the VOC (1=not important; 2=low importance; 3=important; 4=high importance; 5=extremely important).

Table 4.2 Summary of the VOCs in the internal employee survey for the patent filing service

VOCs	Frequency*	Percentage
Cut the time spent by patent engineers on correcting specs., writing disclosure documents, and searching reports	65	89
To be a top-ten patent filing service firm in the nation	59	80
Stabilize the staffing plan during a project implementation	52	71
Clear-cut action plans at each check point in the entire process	44	60
Standardize the format of the customer report	35	48
Improve the communication channel with the client	26	36
Others	18	25

* Same as the remark in Table 4.1 above.

Step 3: Each of the VOCs identified in the last step was further translated into a measurable item. The results of the translations were shown in Figure 4.1 as the main matrix of the house of quality obtained by using QFD.

Relationships

- ▲ Strong positive (Score=9)
- △ Medium positive (Score=3)
- ↑ Weak positive (Score=1)
- ↓ Weak negative (Score=1)
- ▽ Medium negative (Score=3)
- ▼ Strong negative (Score=9)

	Importance to the customer (Scale 1-5)	Cycle time of the patent filing process	Standard deviation of the process cycle times	Provided with regular progress update report	Detailed suggestions covered in customer report	Risk analysis report prepared	Available contingency plans for the patent rework	Process cycle efficiency	Throughput of the patents approved annually	Turnover rate of the project team members during the project implementation	Provided with clear-cut action plans at each check point in the entire process	Degree of standardization of the format of the customer report	Cycle time of a communication between the company and its client
Shorter patent filing interval	5	▼					↑	▲	▲	↓	↑		▽
Stable and consistent schedule for process completion	5		▼						↑	▽			
Regular progress update report	4			▲									↓
Detailed suggestions in customer reports	3				▲								↓
Risk analysis report	2					▲							↓
Contingency plans for the patent rework	2	▽					▲	↑	↑				↓
Cut the time spent by patent engineers on correcting specs., writing disclosure documents, and searching reports	5	▼						▲	▲				
To be a top-ten patent filing service firm in the nation	4	▼						▲	▲				
Stabilize the staffing plan during a project implementation	4	↓	▽							▼			
Clear-cut action plans at each check point in the entire process	3	▽	↓					↑	↑		▲		↓
Standardize the format of the customer report	3											▲	
Improve the communication channel with the client	2	▽	▽					△	△				▼
Importance weighting		151	66	36	27	18	23	137	142	56	32	27	47

Figure 4.1 The translations of the VOCs into measurable requirements by using QFD

Step 4: By looking into the details of the metrics in Figure 4.1, the candidates for being the CTQs were identified as the process cycle time, the throughput for the patents approved annually, and the process cycle efficiency.

However, since the process cycle time had a direct impact on the other two metrics, therefore it was determined to be the CTQ.

Phase 2: Measure/value stream mapping

Step 1: Once the CTQ, i.e., process cycle time, was identified, a data collection plan was then developed and a survey was conducted to gather sample data. In this sample, 70 previous cases during an eight-month period were randomly selected. The data collected was summarized in Table 4.3.

Table 4.3 Data collected for the process cycle time of the patent filing service

CTQ	Average	Std. deviation	Best	Worst
Process cycle time (days)	93	8	50	152

Step 2: A current-state value stream map was constructed as shown in Figure 4.2. By examining this map, two non-value-added steps were identified and should be eliminated. These steps were the professional evaluation and confirming the patent scope. Moreover, as specified earlier in the case, the time spent on drafting the patent specifications by patent engineers was considered to be too long such that it usually results in a lengthy patent filing interval. This reflected a need to change the process cycle time.

Step 3: Prior to the construction of a future-state value stream map, a survey was conducted among customers, employees, and competitors to develop an expected time interval for performing each of the remaining value-added activities. A future-state map was shown in Figure 4.3.

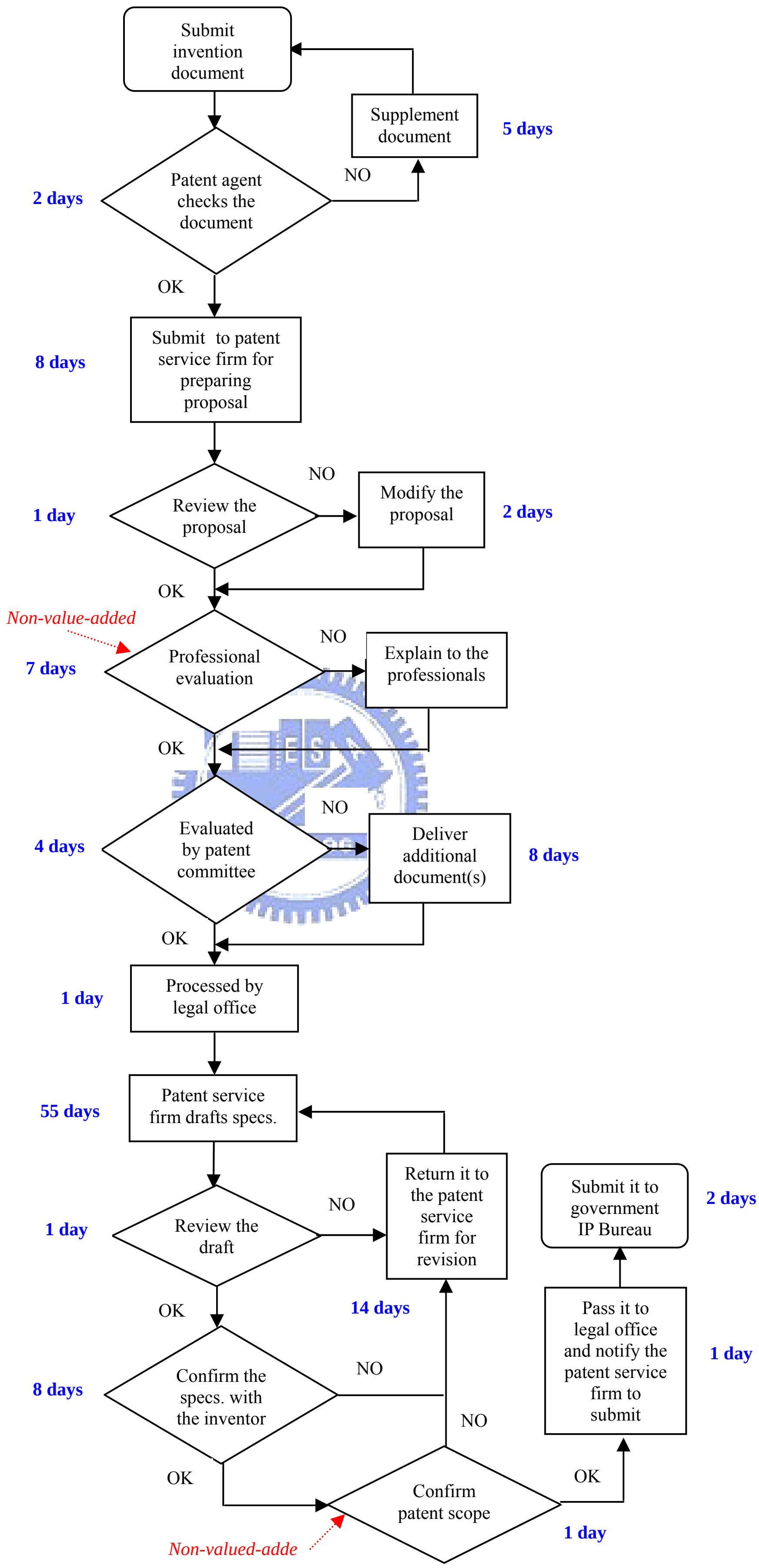

Figure 4 .2 A current-state value stream map for the patent filing service

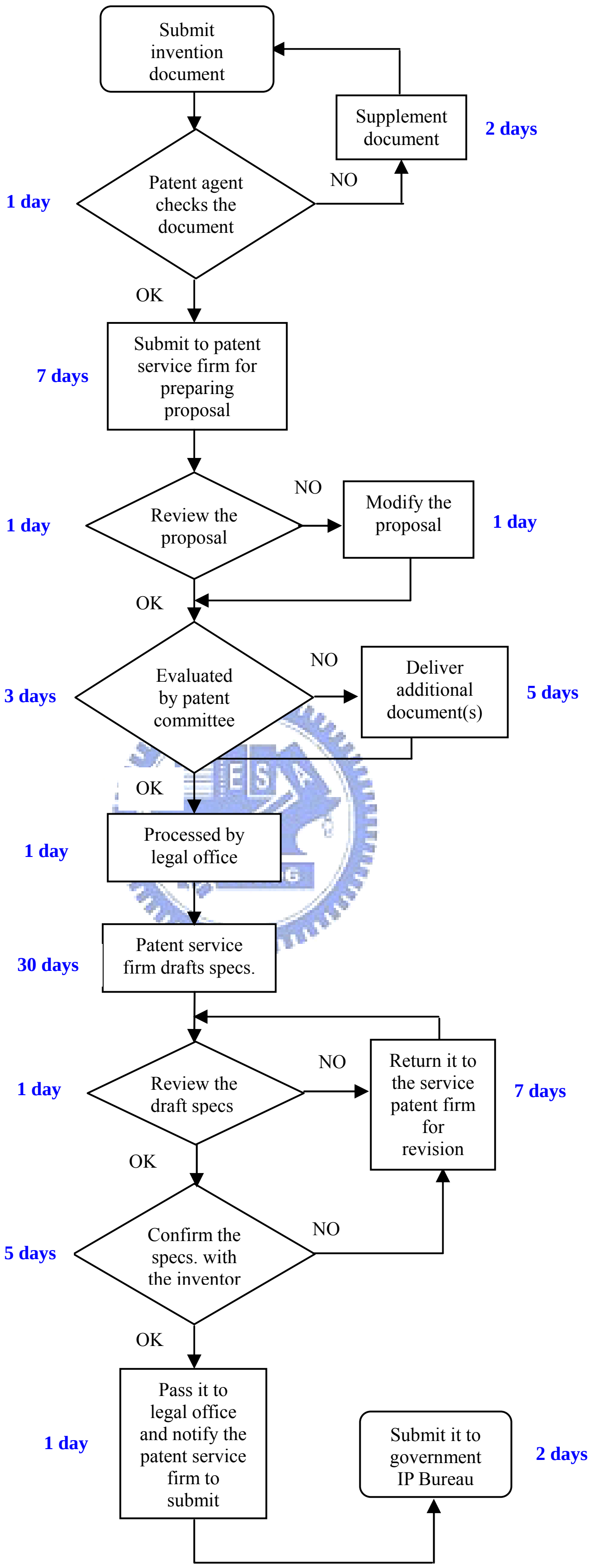

Figure 4.3 A future-state value stream map for the patent filing service

Step 4: A detailed process map was developed and shown in Table 4.4. The input and/or output items in each step of the whole process were identified and established whether or not they are controllable or uncontrollable items.

Table 4.4 A detailed process map for the patent filing service

Process step	VA/ NVA	Input/output items	I/O	Specification levels	Controllable/ uncontrollable
Patent agent checks the invention document	VA	Ideas, figures and descriptions of technology inventions	I	Attain inventive acceptance level	U
	VA	Learn and understand the new technology know-how	I	Understand all the deficiencies of the technology	U
	VA	Time to learn the new technology know-how	O	U: 3 days L: 1 day	C
	VA	Patentability of the new technology	O	U: lower than 100 points (in check list) L: higher than 50 points	C
	VA	Success ratio	O	N/A	U
Supplement document	VA	Time needed to develop supplement document	O	U: 7 days L: 2 day	C
Submit to patent service firm for preparing a proposal	VA	Comprehension level of patent engineers in the patent service firm about the new technology	I	U: zero defects (in check list) L: less than 3 defects	C
	VA	Time needed to complete the disclosure document	O	U: 10 days L: 5 days	C
	VA	Academic background of patent engineers	I	L: must relate to the case type	C
	VA	Working experience of patent engineers	I	L: 2-year experience in patent services	C
Review the proposal by the patent service firm	VA	Time needed to review the disclosure document and searching report	O	U: 2 days L: 1 day	C
	VA	Time needed to modify the disclosure document and searching report	O	U: 3 days L: 1 day	C
	VA	% of without modification	O	N/A	U
Professional evaluation	NVA	Time needed to evaluate the patentability by professionals	O	U: 3 days L: 1 day	C

Table 4.4 A detailed process map for the patent filing service (continued)

Process step	VA/ NVA	Input/output items	I/O	Specification levels	Controllable/ uncontrollable
Evaluated by patent committee	VA	Time needed to prepare presentations by the inventor	O	U: 2 days L: 1 day	C
	VA	Time needed to evaluate the patentability	O	U: 4 days L: 1 day	C
	VA	Time needed to develop supplement documents	O	U: 14 days L: 3 days	C
	VA	% of passing the evaluation	O	N/A	U
Processed by legal office	NVA	Time needed to process the legal concerns	O	U: 2 days L: 1 day	C
Patent service firm drafts specifications	VA	Time needed to draft patent specifications	O	U: 40 days L: 30 days	C
Review the draft specifications	VA	Number of success cases	O	L: 1 success case	C
	VA	Time needed to verify the correlation between disclosure document and the new technology	O	U: 1 day	C
Confirm the specs. with the inventor	VA	Time needed to ascertain the correlation between disclosure document and the new technology	O	U: 7 days L: 2 days	C
Confirm patent scope	NVA	Time needed to determine the boundaries of the patent scope and the new technology	O	U: 2 days L: 1 day	C
Return the patent specs. to the patent service firm for revision	VA	Time needed to revise the patent specs.	O	U: 7 days L: 3 days	C
Pass the patent specs. to legal office and notify the patent service firm to submit the document	VA	Time needed to process legal concerns and issues	O	U: 3 days	C
Submit to government IP Bureau	VA	Time needed to deliver it to the IP Bureau	O	U: 2 days	C

Step 5: The upper and lower specification levels were determined for the process cycle time of each input or output item. These data were also shown in Table 4.4.

Phase 3: Analyze/determine root causation

Step 1: By examining the cycle time data in each step of the current/future-state value stream maps and the detailed process map, the problem of long total process cycle time can be easily analyzed. It was discovered that there existed a huge gap between the ideal and existing amount of time spent on drafting the patent specifications by the patent service firm.

Step 2: The root causes of the long total process cycle time were identified by using the cause-and-effect diagram as shown in Figure 4.4.

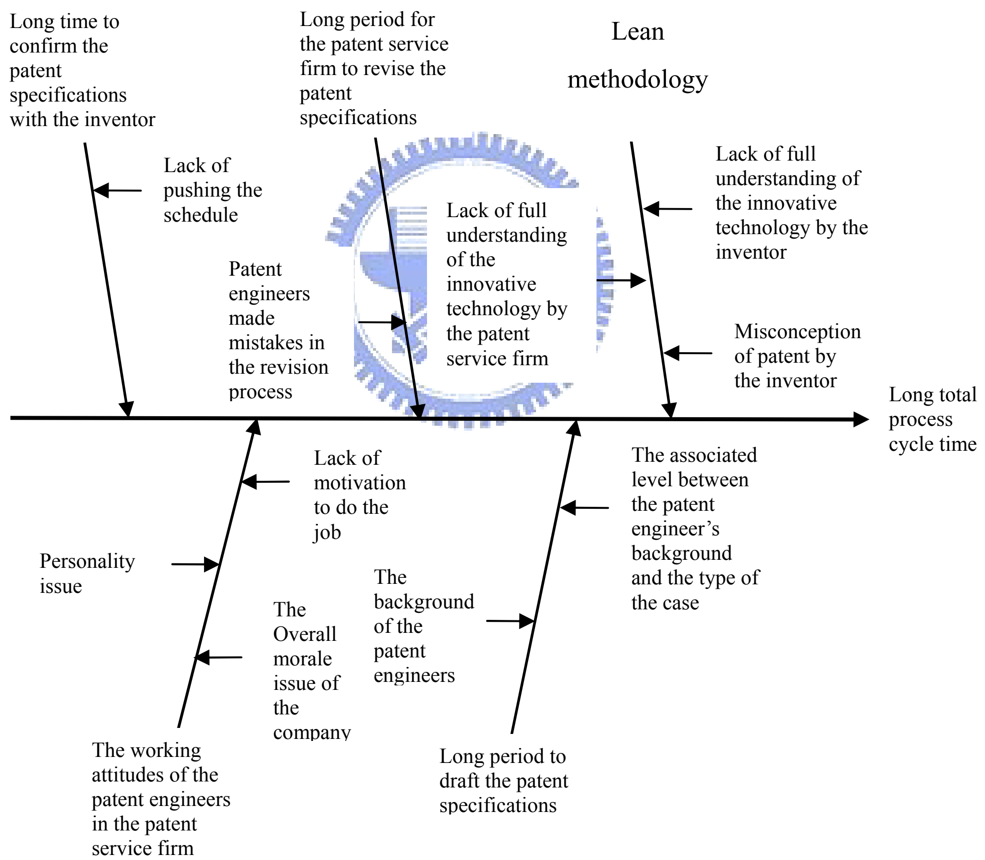

Figure 4.4 The cause-and-effect diagram for the problem of long total process cycle time of the patent filing service

Step 3: Among the root causes as depicted in Figure 4.4, the most significant ones were further identified by utilizing the main effect plots as shown in

Figure 4.5. It was concluded that the background of the patent engineer, and the associated level between the patent engineer's background and the type of the case addressed would have a significant impact on the total process cycle time.

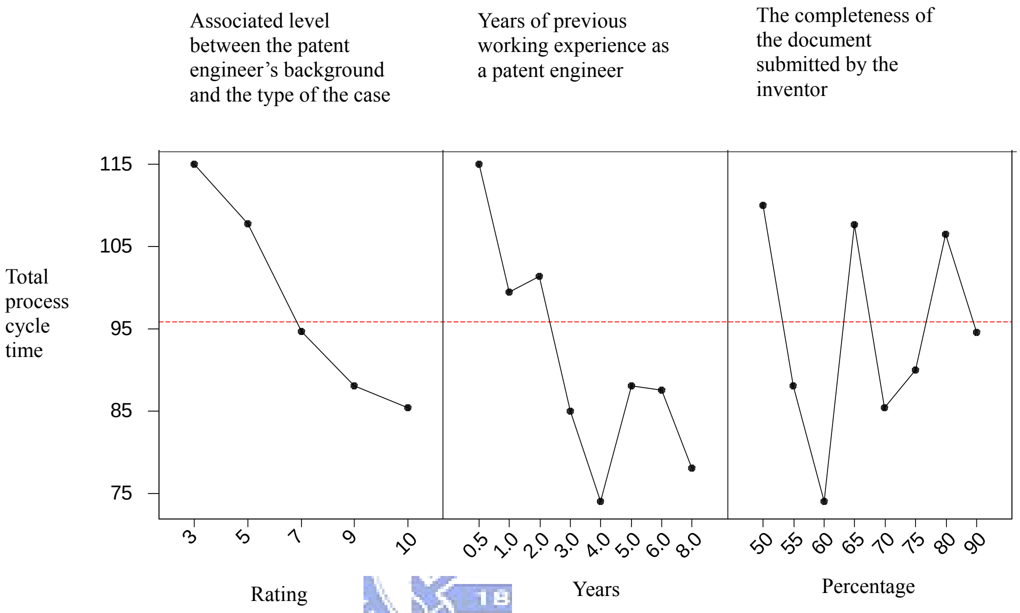

Figure 4.5 The main effect plots for identifying the significant root causes of the patent filing service

Phase 4: *Improve/flow and pull*

Step 1: Based on the findings of the significant causes in the Analyze phase, the solutions to eliminating these causes were proposed after conducting a brainstorming session.

- Set a minimum requirement of at least 2-year previous working experience as a patent engineer;
- The associated level between the patent engineer's background and the type of the case must be higher than 7 points on a 10-point scale.

Step 2: A pull system was developed first by using the solutions proposed in last step to eliminate the significant root causes of the non-value-added steps identified in Figure 4.2. Then, the remaining value-added steps were tightly sequenced such as shown in Figure 4.3 to create an automated flowing process without the need to push services to the customers, but at the pull of the customers.

Phase 5: Control/pursue perfection

Step 1: A control plan was developed which involves the use of a Check List for the internal strategic management, and an R-chart for the long term patent filing time interval control.

Step 2: As a control plan was established, it was implemented all along with proceeding in the service process.

4.1.3 The implementation results and discussions

A follow-up study was conducted after the patent service firm had implemented the Lean Six Sigma methodology. A total of 68 sample cases had been randomly picked up for this study. The comparisons of results were summarized in Tables 4.5 through 4.7 as follows.

Table 4.5 Overall performance of the Lean Six Sigma project for patent filing service

CTQ	Before		Target		After	
	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
Process cycle time (days)	93	8	75	3	63.3	2.5

Table 4.6 Breakdown analysis by steps for the process of patent filing service

Steps	Average process cycle time (days)		
	Before	Target	After
Patent agent checks the document	2	1	1
Supplement document submitted	5	3	2
Submit to a patent service firm for preparing a proposal	8	8	7
Review the proposal by the patent service firm	1	1	1
Modify the proposal	2	2	1
Evaluated by patent committee	4	3	3
Supplement additional document	8	8	7
Processed by legal office	1	1	1
Patent service firm drafts specifications	55	40	36
Review the draft specifications	1	1	1
Return the patent specs. to the service firm for revision	14	7	7
Confirm the specs. with the inventor	8	7	6
Pass the patent specs. to legal office and notify the patent service firm to submit the document	1	1	1
Submit to government IP Bureau	2	2	2

Table 4.7 The financial results of the Lean Six Sigma project for patent filing service

Savings (US$/year)	Target	Actual
Hard savings	76,610	93,750
Soft savings	23,560	27,340
Total savings	100,170	121,090

One of the major findings in this study was that the average total process cycle time for a patent filing service case was reduced by 29.7 days or 31.9% equivalent compared with the patent filing performance before implementing the Lean Six Sigma methodology, and it also exceeds the firm's target number, i.e. 75 days. This achievement in cycle time reduction implies that the Lean Six Sigma methodology has made a case that it can help accelerate the process flow by eliminating the non-value-added steps and streamlining the remaining value-added steps. In addition, this result also means that the patent filing interval can be enhanced through the use of this Lean Six Sigma process.

Another issue that confronted the firm was the inherent variations in schedule for completing the patent filing cycle. Such an issue is reflected by the statistical standard deviations of the process cycle time over the sampling distribution of this study. Again, it is encouraging to see that the standard deviation has decreased by 5.5 days or 68.8% equivalent and, meanwhile it outperforms the target performance level. These results indicate that a more stable and consistent schedule for the completion of a patent cycle was established, which was a significant improvement over the results obtained prior to the implementation of the Lean Six Sigma methodology.

Using Six Sigma terminology, this project achieved a 4.68-sigma quality level result combining hard and soft savings valued at US$121,090 using an extrapolation to the obtained data upon a one-year period. In this project case, the one-year total hard savings from reductions in human effort account for US$93,750, which was derived from the calculations of the average employee salaries. On the other hand, the soft savings primarily gained from litigation, infringement, licensing, and intellectual property (IP) rights accumulated to US$27,340 on a twelve-month basis.

4.2 Case: IT help desk service

4.2.1 The background of the case

The case study is a practical project that we had been involved in improving the service level of the IT help desk service division in a multinational company with its headquarters in Taiwan. The primary functions of the division cover the areas of the management of the company-wide computer network systems, supporting office automation activities, data processing and management, and IT technical consulting. However, too often the divisional managers receive complaints from their employees and external customers that the IT service processing time is frequently much longer than they expected. Such an issue of lengthy service processing time has the potential to directly impact the employee's work efficiency and the effective communications with the customer, and thus eventually affects the corporate performance and customer relationships. Other issues include a lack of a complete and sound Standard Operations Procedure (SOP) to guide the personnel in the division for handling the service requests in an efficient manner, insufficient number of employees to take care of the situation of the ever-increasingly crowded service requests, and the ineffectiveness of coping with the fast changing types of service issues confronting the existing outmoded hardware, software and other equipment.

4.2.2 Implementing the Lean Six Sigma methodology

Phase 1: Define/identify value

Step 1: The voices of both customers and employees can be identified as follows.

- Shorter IT service processing time needed to take care of service requests. This issue relates to the *responsive* dimension of the service quality.

- Establish a SOP in order to efficiently respond to service requests by the employee and customer. This issue relates to the *assurance* dimension.
- An appropriate staffing plan for relieving the work overload on the employee. This issue relates to the *responsive* dimension.
- Replace or upgrade the current aging equipment to effectively handle any type of service issues. This is concerned with the *tangibles* dimension.

Step 2: Concerning the key attributes identified in Step 1, we translate each of those attributes into a measurable item as follows.

- A *cycle time* can directly link to the service processing time needed to take care of a service request.
- A *process cycle efficiency* relates to the amount of value-added time to the total lead time of the process (George, 2003). It can be a metric for measuring the work efficiency of the employee in the division.
- A *throughput rate* can be an indicator for examining the appropriateness of the staffing plan.
- A *throughput* index may reflect the effectiveness of the equipment used to handle any potential service issues.

Step 3: By applying the Kano model to identifying the CTQs, the metrics defined in step 2 can be further analyzed based on the perspectives of the majority of 120 employees and 72 customers respectively who were randomly selected for answering the pre-designed questionnaires, and the results were summarized in Table 1. Although the four metrics are all regarded to be important by either the employee or customer, however, since the cycle time has a direct impact on the other three metrics, therefore, it dominates over the others for the determination of the CTQs.

Table 4.8 The Kano model analysis for the determination of the CTQs

Metrics	Customer's perspective	Employee's perspective
Cycle time	Performance	Indifferent
Process cycle efficiency	Basic	Basic
Throughput rate	Indifferent	Basic
Throughput	Basic	Basic

Phase 2: Measure/value stream mapping

Step 1: Once the CTQ, i.e. cycle time, was identified in the Define phase, a data collection plan was developed to gather sample data. In this sample, 110 service requests in a total of 22,413 were randomly selected for a survey for a certain twelve-month time period before the project started. The data collected is summarized in Table 4.9.

Table 4.9 Data collected for the cycle time of the IT help desk service

CTQ	Average (minutes/request)	Std. deviation (minutes)	Sigma level (USL=180 minutes) *
Cycle time	167.5	81.6	0.15

Step 2: Construct a current-state value stream map as shown in Figure 4.6. By examining this map, one non-value-added step is identified and should be eliminated. It is the step which asks the user to provide correct and

* The upper specification level (USL) will be determined in the step 5 of the Measure phase.

complete information in order to expedite the service delivery.

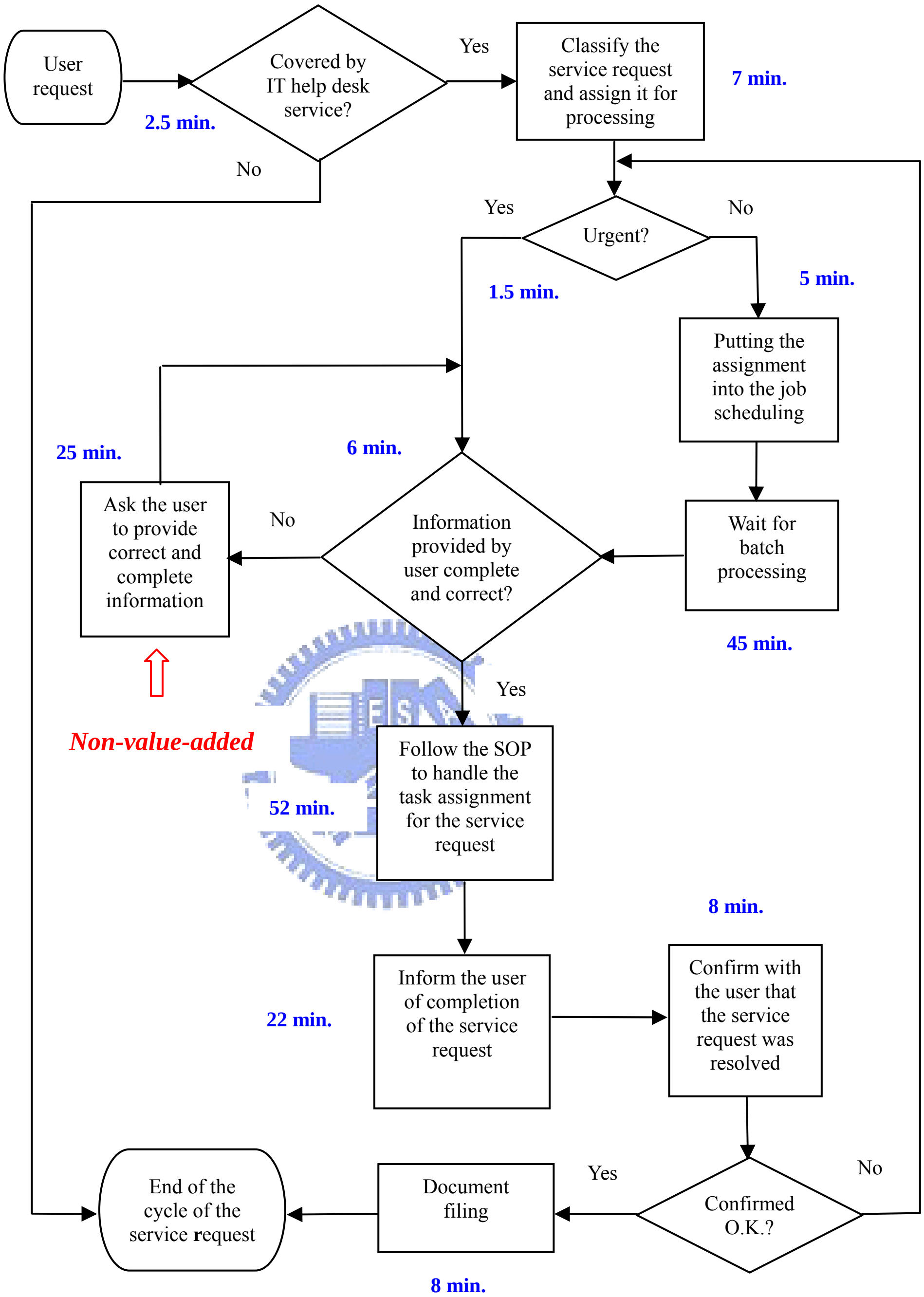

Figure 4.6 A current-state value stream map for the IT help desk service

Step 3: To construct a future-state value stream map as shown in Figure 4.7, eliminate the non-value-added step from the process, and try to find any potential for reducing the cycle time in each of the remaining steps.

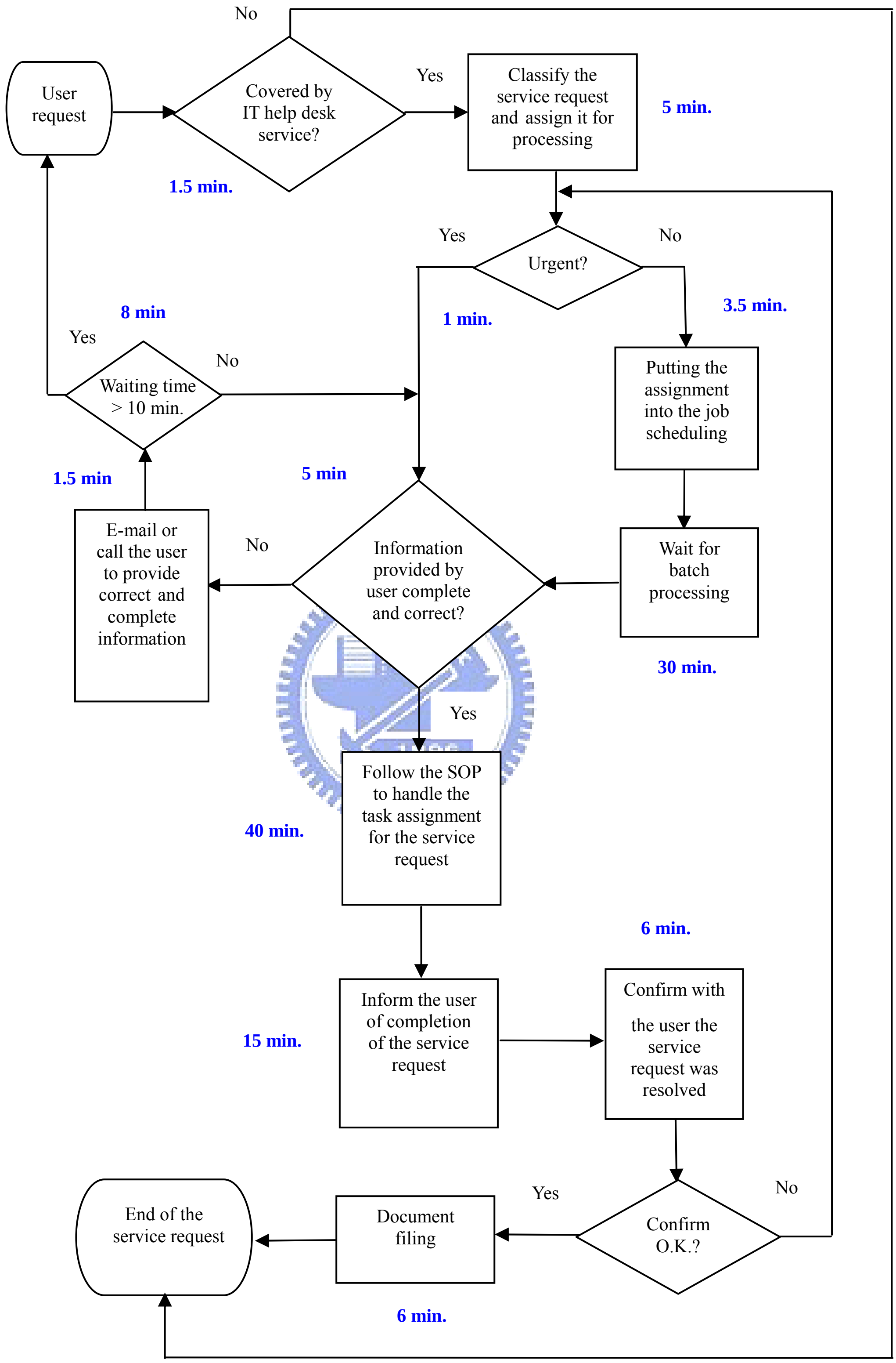

Figure 4.7 A future-state value stream map for the IT help desk service

Step 4: Then, a detailed process map was developed as shown in Table 4.10. The input/output items in each step of the whole process are identified and established whether or not they are controllable or uncontrollable items.

Table 4.10 A detailed process map for the IT help desk service

Process step	**VA / NVA**	**Input / output items**	**I/O**	**Specification Levels**	**Controllable/ Uncontrollable**
Check if the service request is covered by the IT help desk service	VA	Request form	I	N/A	C
	VA	Judgment based on experience	I	U: 3 minutes	C
	VA	IT help desk guideline list	I	Based on the procedure descriptions	C
	VA	Conclusion on whether the service request is covered by the IT help desk service or not	O	N/A	C
Classify the service request and assign it for processing	VA	Check list for the service request	I	N/A	C
	VA	Level of the technical expertise possessed by the staff in the IT help desk service division	I	L: at least one year of field experience	C
	VA	Task assignment for the service request	O	N/A	C
Judge whether the service request is urgent or not	VA	Type of the service request	I	N/A	C
	VA	The impact level of the service issue	I	N/A	U
	VA	The position level of the user	I	L: divisional managers	U
	VA	Decision on whether to take action immediately or not	O	N/A	U
Put the task assignment into the job scheduling	VA	Request form	I	N/A	C
	VA	Current job scheduling for an individual	I	N/A	C
	VA	Waiting time for processing	O	N/A	C
Check whether the information provided by the user is correct and complete	VA	Problem confirmation	I	N/A	U
	VA	Confirmation of the abnormal messages	I	U: 3 minutes	C
	VA	Confirmation of the user's computer environment	I	U: 3 minutes	C
	VA	Confirm the authority levels for execution	I	U: 3 minutes	C
	VA	Confirm the operational procedures	I	U: 3 minutes	C
	VA	Confirmation of the correctness and completeness of the information provided by the user	O	N/A	C

Table 4.10 A detailed process map for the IT help desk service (continued)

Process step	VA / NVA	Input / output items	I/O	Specification Levels	Controllable/ Uncontrollable
Ask the user to provide correct and complete information	NVA	E-mail or call the user to provide additional information	I	N/A	C
	NVA	Waiting time for the user to provide additional information	O	U: 30 minutes	C
Follow the SOP to handle the task assignment for the service request	VA	Prepare a guideline for taking care of the abnormalities .	I	N/A	C
	VA	Prepare for tools needed (hardware and software)	I	N/A	C
	VA	Coordination of related people	I	N/A	U
	VA	Trouble shooting	O	U: 90 minutes	C
	VA	Write a task report	O	U: 15 minutes	C
	VA	Total processing time need for this step	O	U: 120 minutes	C
Inform the user of completion of the service request	V/A	Inform the user of completion of the service request by e-mail or phone	I	N/A	C
	V/A	Time needed for receiving user's response	O	U: 30 minutes	U
Confirm with the user that the service request was resolved		The user spends time on the confirmation	I	U: 15 minutes	C
	V/A	Result of the confirmation	O	N/A	U
Document filing	V/A	The documents prepared for filing	I	N/A	C
	V/A	Update the guideline for handling the abnormalities	O	Update after the confirmation	C
	V/A	Close the job scheduling for the service request	O	Update after the confirmation	C

Step 5: Referring to the data of the current specification levels for the cycle time in each process step as shown in Table 3, we set the upper specification level for the total service processing time at 180 minutes, while the lower specification level is left blank since the service processing time is less, the better the service quality is.

Phase 3: Analyze/determine root causation

Step 1: By looking into the average cycle time data in each step of the current-state and future-state value stream maps, it was easily discovered that there exist two major gaps between the ideal and existing amount of time spent on following the SOP to handle the task assignment for a service request and asking the user to provide correct and complete information respectively.

Step 2: The root causes of the problem of long service processing time were identified by using the cause-and-effect diagram as shown in Figure 4.8.

Step 3: Among the root causes as depicted in Figure 4.8, the significant ones were further identified by utilizing the Main Effect Plots as shown in Figure 4.9. We concluded that the root causes of the lack of a well-proven SOP to be followed for performing the task assignment and the inappropriate level of technical expertise possessed by the assigned IT staff would have a significant impact on the service processing time.

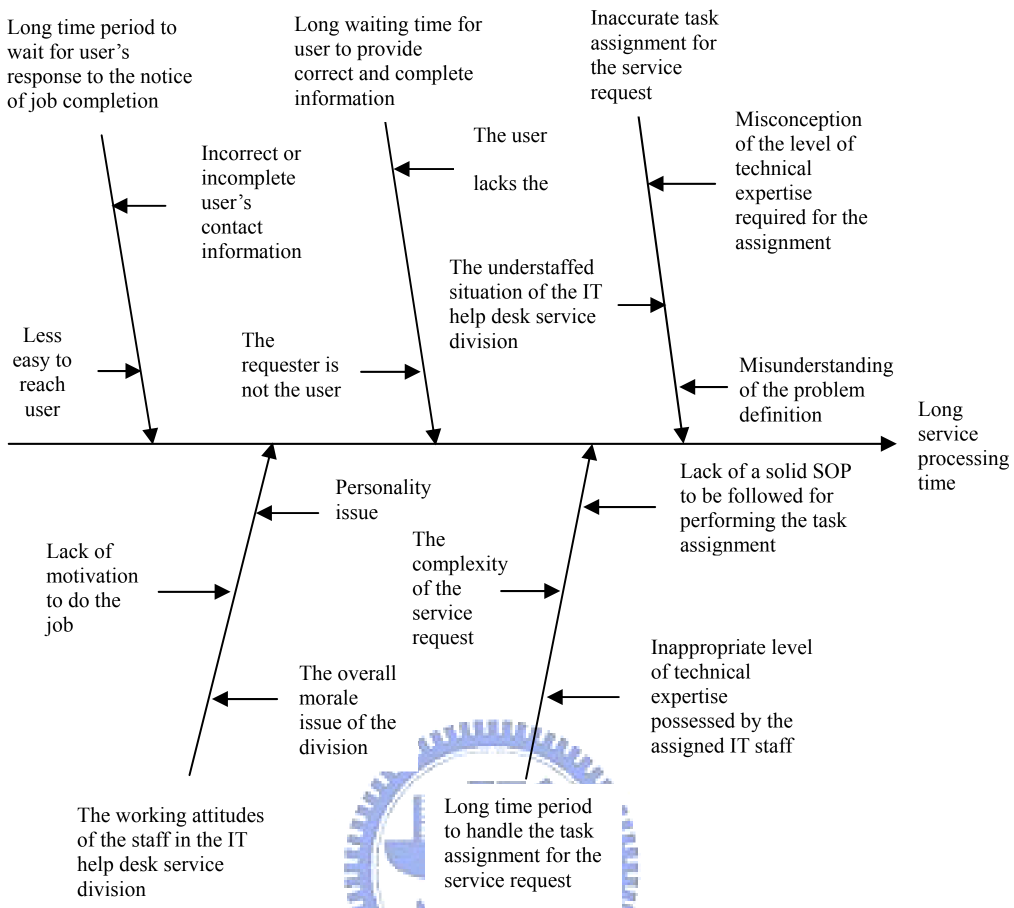

Figure 4.8 The cause-and-effect diagram for the problem of long service processing time of the IT help desk service

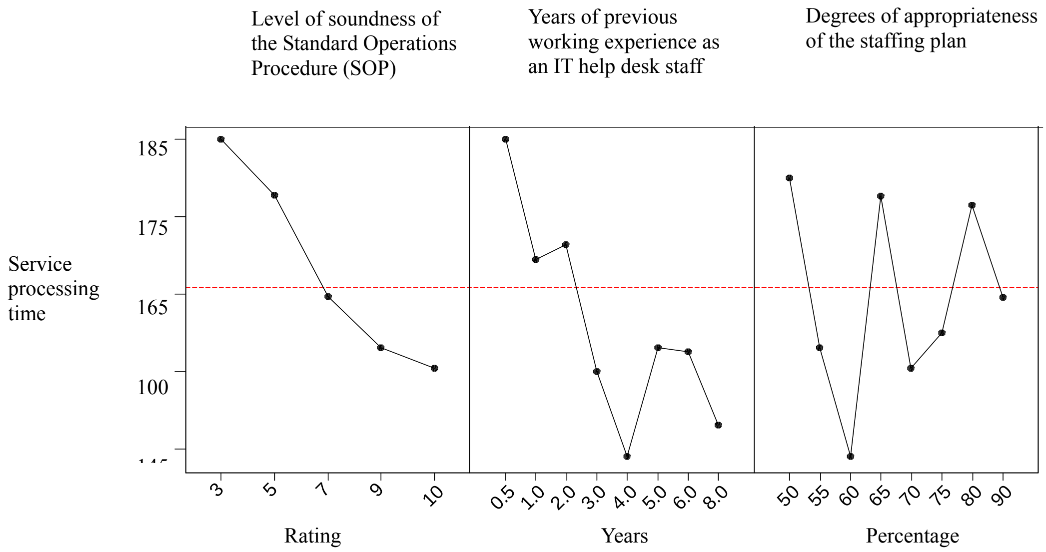

Figure 4.9 Main effect plots for identifying the significant root causes of the IT help desk service

Phase 4: *Improve/flow and pull*

Step 1: Based on the findings of the significant causes in the Analyze phase, the solutions for eliminating these causes are proposed as follows.

- Examine and revise, if necessary, the current SOP in order to help deliver the services more smoothly and quickly. In addition, building up a knowledge base for the IT help desk service can also substantially benefit the shortening of the service processing time.
- Set a minimum requirement of at least 2-year previous experience as an IT help desk staff, and confirm his/her levels of technical expertise by the proven success record on the job assignment.

Step 2: A flow and pull system can be developed by following the process as shown in the future-state value stream map. This new system features a streamlined process flow and specified customer-driven demand.

Phase 5: Control/pursue perfection

Step 1: Develop a control plan which involves the use of a Check List for the internal strategic management, and an R-chart for the long-term service processing time control.

Step 2: As a control plan is established, implemented and completed, then, it is recycled through the entire service process.

4.2.3 The implementation results and discussions

A follow-up study was conducted after the IT help desk service division had implemented the Lean Six Sigma methodology. A total of 437 sample cases were randomly selected for this three-month study. The comparisons of results are summarized in Tables 4.11 through 4.1 as follows.

Table 4.11 Overall performance of the Lean Six Sigma project for the IT help desk service

CTQ	Before		Target		After	
	Average	**Std. dev.**	**Average**	**Std. dev.**	**Average**	**Std. dev.**
Cycle time (minutes)	167.5	81.6	112.0	49.3.	88.0	23.2

Table 4.12 Breakdown analysis by steps for the process of the IT help desk service

Steps	Average cycle time (minutes)		
	Before	**Target**	**After**
Check if the service request is covered by the IT help desk service	2.5	1.5	1.5
Classify the service request and assign it for processing	7.0	5.0	4.0
Judge whether the service request is urgent or not	1.5	1.0	1.0
Put the task assignment into the job scheduling	5.0	3.5	2.5
Wait for batch processing	45.0	30.0	22.0
Check whether the information provided by the user is correct and complete	6.0	5.0	3.5
Ask the user to provide correct and complete information	25.0	9.5	8.0
Follow the SOP to handle the task assignment for the service request	52.0	40.0	36.0
Inform the user of completion of the service request	22.0	15.0	13.0
Confirm with the user that the service request was resolved	8.0	5.0	5.0
Document filing	8.0	6.0	4.5

Table 4.13 The financial results of the Lean Six Sigma project for the IT help desk service

Savings (US$/year)	Target	Actual
Hard savings	75,684	92,963
Soft savings	24,755	28,340
Total savings	100,439	121,303

One of the major findings in this study was that the average service processing time for a case of IT help desk service was reduced by 79.5 minutes or 47.5% equivalent compared with the performance before implementing the Lean Six Sigma methodology, and it also exceeds the firm's target number of 112 minutes. This achievement in cycle time reduction implies that the Lean Six Sigma methodology has proven its power to accelerate the process flow by eliminating the non-value-added steps while also streamlining the remaining value-added steps. In addition, it is encouraging to see that the standard deviation has decreased by 58.4 minutes or 71.6% equivalent. These results indicate that a more stable and consistent service processing time interval was established.

Using Six Sigma project terminology, this project achieved a 3.97-sigma quality level result combining both hard and soft savings valued at US$121,303 annually based on the calculations of the obtained data. The hard savings refer to the Six Sigma project benefits that allowed this firm to do same amount of business with fewer employees or handle more business without adding people. On the other hand, soft savings are Six Sigma project benefits such as reduced time to market, cost avoidance, improved employee morale, and other intangibles which contributed additional savings to the firm.

4.3 Case: software development process

4.3.1 The background of the case

The specific case studied in this research is a practical project that involves in redesigning the software development processes of a software house with its headquarters located in Taipei, Taiwan. Today, the company is operating the business in more than twenty countries across the regions of Asia Pacific, South Asia, and North America. To compete in the market, the strategic focus of the company is on the sector of small and medium-sized enterprises (SMEs), and currently there is a total of over 35,000 SMEs, which constitute its major customer base.

Since established in 1998, the company has grown up rapidly in its business while at the same time experiencing some operational challenges from the competitors. The key issue that the company was facing and had to resolve is to continue providing customers with high-quality and price-competitive software applications and related services in a timely fashion in order to compete in the market. However, the processes for software development before the project implementation obviously could not keep up with the pace of the considerable changes in customer demands. Therefore, a major thrust for the company to redesign the software development processes is to reflect such an issue as specified.

4.3.2 Implementing the Design for Lean Six Sigma methodology

In early 2004, the company started the nine-month project case, and the methodology proposed in this paper was followed through by the project team. The specific steps of the project implementation are described in detail as follows.

Phase I: Define

Step 1: First of all, a project charter is established at the outset of the project implementation. Once the prerequisite such as project goals, scope, and necessary resources are clearly defined, the subsequent steps then can be followed to proceed. For example, the company has set the project goals as follows.

- To achieve a 15 percent market share of e-business solutions in the Asia market by the end of the year 2005;
- To obtain a 25 percent growth rate of total revenue in 2005; and
- To sustain at least 30 percent overall profit margin in 2005.

Step 2: Secondly, two surveys are conducted separately to identify what the customer really wants. One of the surveys has a total of 196 effective responses out of the 225 external customers that are randomly selected from the existing client base. The other one survey includes 72, in total, effective responses out of the 76 internal customers that are picked up from the corporate employees. The VOCs are gathered and summarized as shown in Tables 4.14 and 4.15. For the simplicity of this project research, the VOCs are selected and defined as those items in the surveys with a given priority level of high or extreme importance by one or more of the respondents.

Table 4.14 Summary of the VOCs in the external customer survey for the software development process

VOCs	Frequency*	Percentage
Customizable software systems	182	93
Quick order delivery	173	88
Consistent schedule for order delivery	152	78
Compatible with other operating systems or software applications	112	57
User friendly system interface	98	50
Easy system setup, installation, and maintenance	79	40
Providing on-site customer support	56	29
Low cost for version upgrade	35	18
Reasonable charge for technical support	27	14
Downloadable service pack for system defects	22	11
Online interactive system help menu	9	5

* The frequency was accumulated by counting the number of those responses which gave the priority level of at least 4 to each specific item in the VOCs (1=not important; 2=low importance; 3=important; 4=high importance; 5=extremely important).

Table 4.15 Summary of the VOCs in the internal employee survey for the software development process

VOCs	Frequency*	Percentage
Shortened software development cycle	68	94
Faster make-or-buy decision making processes	59	82
Effective and timely communications within the supply chain	53	74
Improved collaborative models for the software development teams located in different countries	47	65
Integrated customer relationships management (CRM) systems for handling customer services	38	53
Easy to access and maintain the source codes of the software developed by different teams	24	33
To be an Asia market leader in e-business solutions	19	26
Stabilized staffing plan during the implementation of a development project	6	8

* Same as the remark in Table 4.14 above.

Step 3: A simple affinity diagram can be used to categorize the VOCs identified in the last step based on the five dimensions of service quality. The completed affinity diagram for the categorization of the VOCs is shown in Figure 4.10. It is noted that all of the items in the VOCs are eligible to be categorized into a specific dimension of the service quality. Thus, all of the identified VOCs should be taken into account as the factors that would affect the service quality level. In addition, to prioritize the VOCs, the percentage orders shown in Tables 4.14 and 4.15 are adopted to serve the purpose. In other words, the larger the percentage is, the higher the priority level is given.

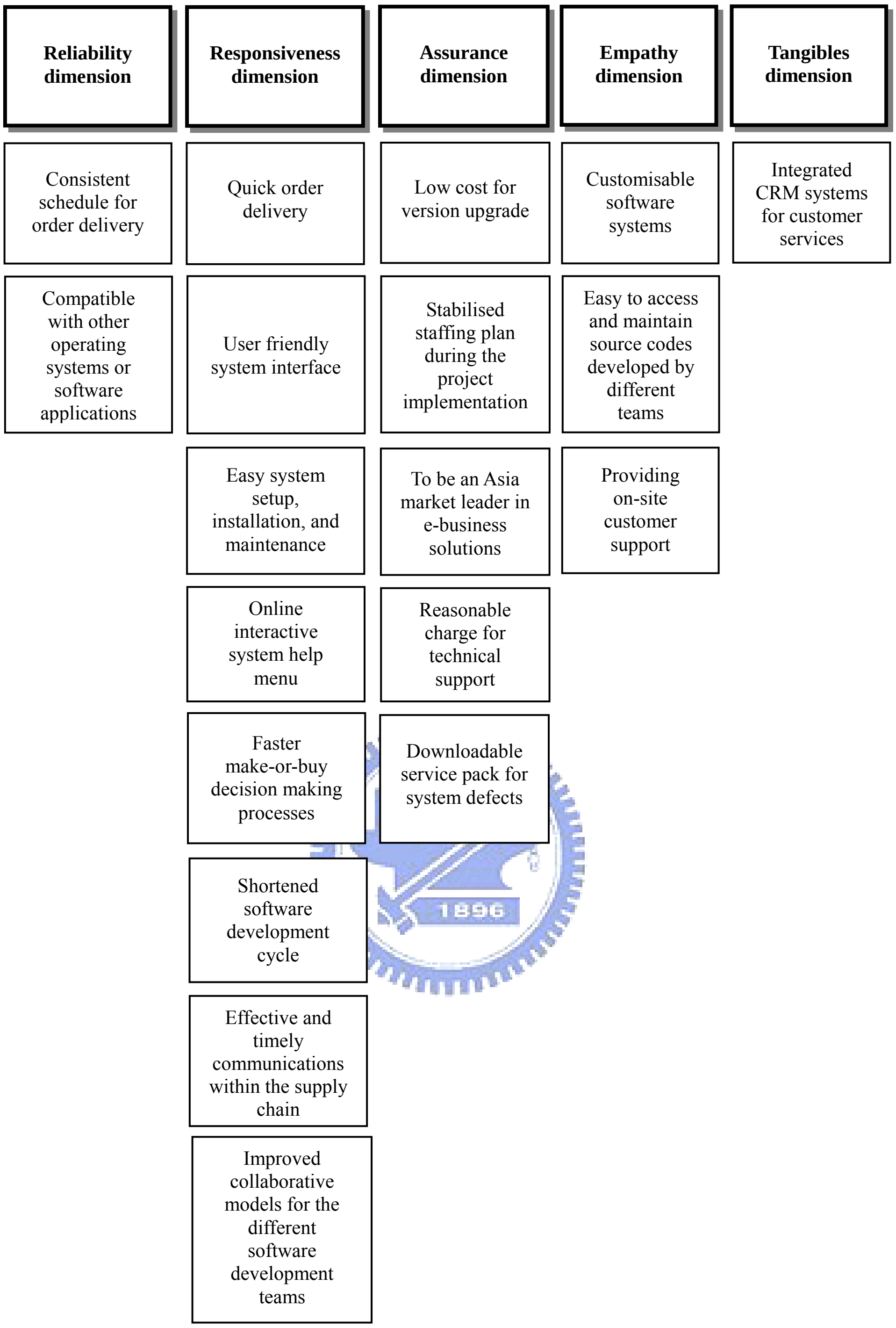

Figure 4.10 Categorization of the VOCs by using an affinity diagram

Phase II: Measure

Step 1: In this step, all of those categorized and prioritized VOC items in the previous phase are translated into measurable requirements/CTQs from the design perspective. The result of the translation is shown in Figure 4.11 as the main matrix of the house of quality obtained by using QFD.

Relationships

- ▲ Strong positive (Score=9)
- △ Medium positive (Score=3)
- ↑ Weak positive (Score=1)
- ↓ Weak negative (Score=1)
- ▽ Medium negative (Score=3)
- ▼ Strong negative (Score=9)

	Importance to the customer (Scale 1-5)	Percent level of customer satisfaction with the customisation	Cycle time for order delivery	Variation of the cycle time for order delivery	Number of the cases in which the issues of system incompatibility reported	Time needed to learn to operate the system interface	Cycle time for the system setup, installation, and maintenance	Total time of on-site customer support annually	Total cost for each version upgrade	Charge rate for technical support	Number of system defects discovered	Provided with online problem-solving guides	Cycle time for the software project development	Cycle time for the make-or-buy decision making process	Cycle time for a communication within the supply chain	Throughput rate for the project development through collaboration among different teams	Throughput rate for handling customer services via the CRM systems	Cycle time for an access to source codes developed by different teams	Market share in the Asia market of e-business solutions	Turnover rate of the project team members during the project implementation
Customisable software systems	5	▲			▽					▽	▽	↑								
Quick order delivery	5	▽	▼		▽						▽		▼	▼	▽			▽		↓
Consistent schedule for order delivery	4			▼	↓						↓									▽
Compatible with other operating systems or software applications	3				▼						▽									
User friendly system interface	3	△			▽	▼	▼				▽	△								
Easy system setup, installation, and maintenance	2	△			▽	▽	▼				▽	△								
Providing on-site customer support	2							▲				↓					▽			
Low cost for version upgrade	1								▼											
Reasonable charge for technical support	1	▽			▽			▽		▼	▽	↑					↑			
Downloadable service pack for system defects	1				▽						▼									
Online interactive system help menu	1						▽					▲								
Shortened software development cycle	5	▽			▽						▽		▼	▼	▽	↑		▽		↓
Faster make-or-buy decision making process	5													▼	↓					
Effective and timely communications within the supply chain	4														▼					
Improved collaborative models for the software development teams located in different countries	4														▽	▲		▽		
Integrated customer relationship management (CRM) systems for handling customer services	3														▽		▲			
Easy to access and maintain the source codes of the software developed by different teams	2														↓			▼		↓
To be an Asia market leader in e-business solutions	2	△	▼	▼	▼				▼	▽	▼		▽						▲	
Stabilised staffing plan during the implementation of a development project	1																			▼
Importance weighting		99	63	54	115	33	48	21	27	30	103	32	96	135	94	36	38	60	18	33

Figure 4.11 The translation of the VOCs into measurable requirements by using QFD

Step 2: The measurable requirements/CTQs identified in Figure 4.11 are further prioritized based on the calculations of importance weightings in the

QFD matrix which is also shown in Figure 4.11. Next, Using Pareto analysis, those few CTQ items that account for the substantial portion of the total importance weighting are selected to establish the performance metrics as follows.

- Cycle time for the make-or-buy decision making process;
- Number of the cases in which the issues of system incompatibility reported;
- Number of system defects discovered;
- Percent level of customer satisfaction with the customization;
- Cycle time for the software project development; and
- Cycle time for a communication within the supply chain.

Step 3: By using the methods of customer surveys among both internal and external customers, as well as benchmarking and competitive analysis within the industry, the specification levels that represent a range of acceptability for each performance metric are determined in Table 4.16.

Table 4.16 The specification levels for the performance metrics

CTQ	Specification levels	
	Upper level	**Lower level**
Cycle time for the make- or-buy decision making process	40 days	N/A**
Number of the cases in which the issues of system incompatibility reported	1,350 DPMO*	N/A**
Number of system defects discovered	2,555 DPMO*	N/A**
Percent level of customer satisfaction with the customization	N/A**	60 %
Cycle time for the software project development	130 days	N/A**
Cycle time for a communication within the supply chain	7 days	N/A**

* DPMO stands for defects per million opportunities.
** N/A indicates that the data is not available.

Phase III: Analyze

Step 1: Since the performance metrics have been established in the last phase, this step takes the metrics into the design requirements and starts to develop conceptual process design alternatives. However, one contradictory issue exists when all of the performance metrics are taken into account. That is the contradiction between the two metrics of the percent level of customer satisfaction with the customization and the cycle time for the software project development. To overcome this dilemma, TRIZ technique (Altshuller, 2004) is adopted by referring to its *contradiction matrix* and *40 principles*. In this case, a reference is made to the mapping between the two parameters, 'adaptability' and 'speed', in the *contradiction matrix*, and one suggested solution, 'preliminary action', can be obtained by consulting the *40 principles*. As a result, an idea of developing modularized designs of software applications can be derived from the solution suggested by TRIZ. Finally, two conceptual design alternatives are generated and described respectively as follows. *Alternative 1*: the company may initiate an in-house project for dealing with the customer's request for software development. *Alternative 2*: the company may outsource some independent software development firms for fulfilling its customers' orders for new software designs.

Step 2: Based on the conceptual design alternatives developed in the last step, an initial-state value stream map can be constructed for each alternative. An example of such a map is outlined in Figure 4.12 for Alternative 2. In this example, there are two process steps identified to be non-value-added by applying Lean principles. They are the steps of 'Confirm with R&D' and 'Tested by product marketing', which also expose the opportunities for design improvements.

Step 3: To evaluate the design alternatives, further examinations on their respective value stream maps are required. In this case, both of the two design alternatives can be evaluated and compared in terms of the cycle time data for each process step in the value stream maps. For example, the cycle time data, which is obtained based on the practical experience, for Alternative 2 is also depicted in Figure 4.12. As a result, Alternative 2 is preferable to Alternative 1 by comparison between their total process cycle times, and therefore is selected to be the option for further design work.

Step 4: The design work begins with the improvement on the initial-state value stream map. It means first to eliminate the non-value-added process steps as identified in Step 2 of this phase. Next, a future-state value stream map can be constructed as shown in Figure 4.13 to represent a desired performance level. It is noted that the non-value-added step, 'Tested by product marketing', in Figure 4.12 is eliminated and replaced by a new value-added step called 'Tested on partner's platform' as exhibited in Figure 4.13.

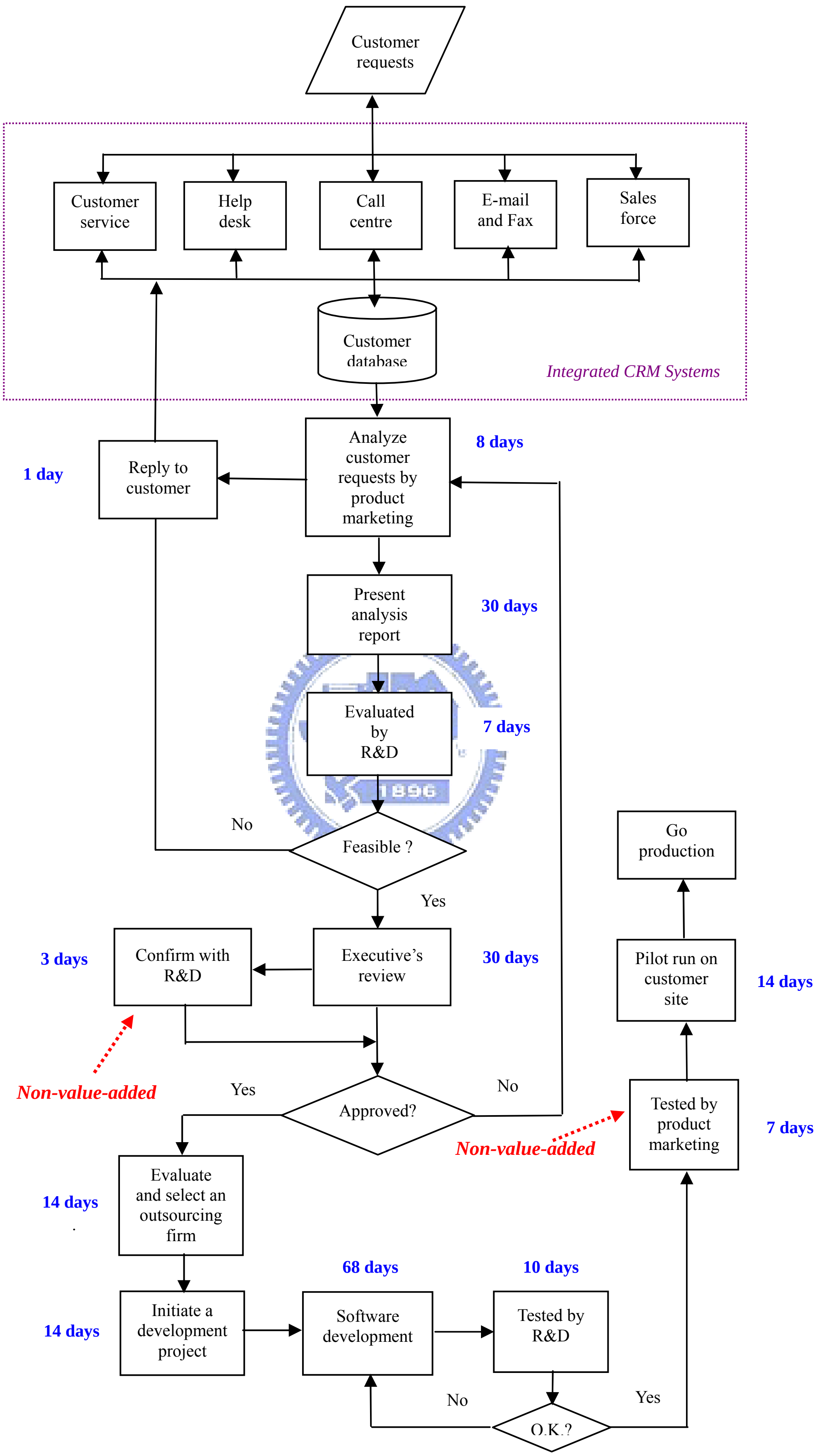

Figure 4.12 An initial-state value stream map for Alternative 2 of the software development process

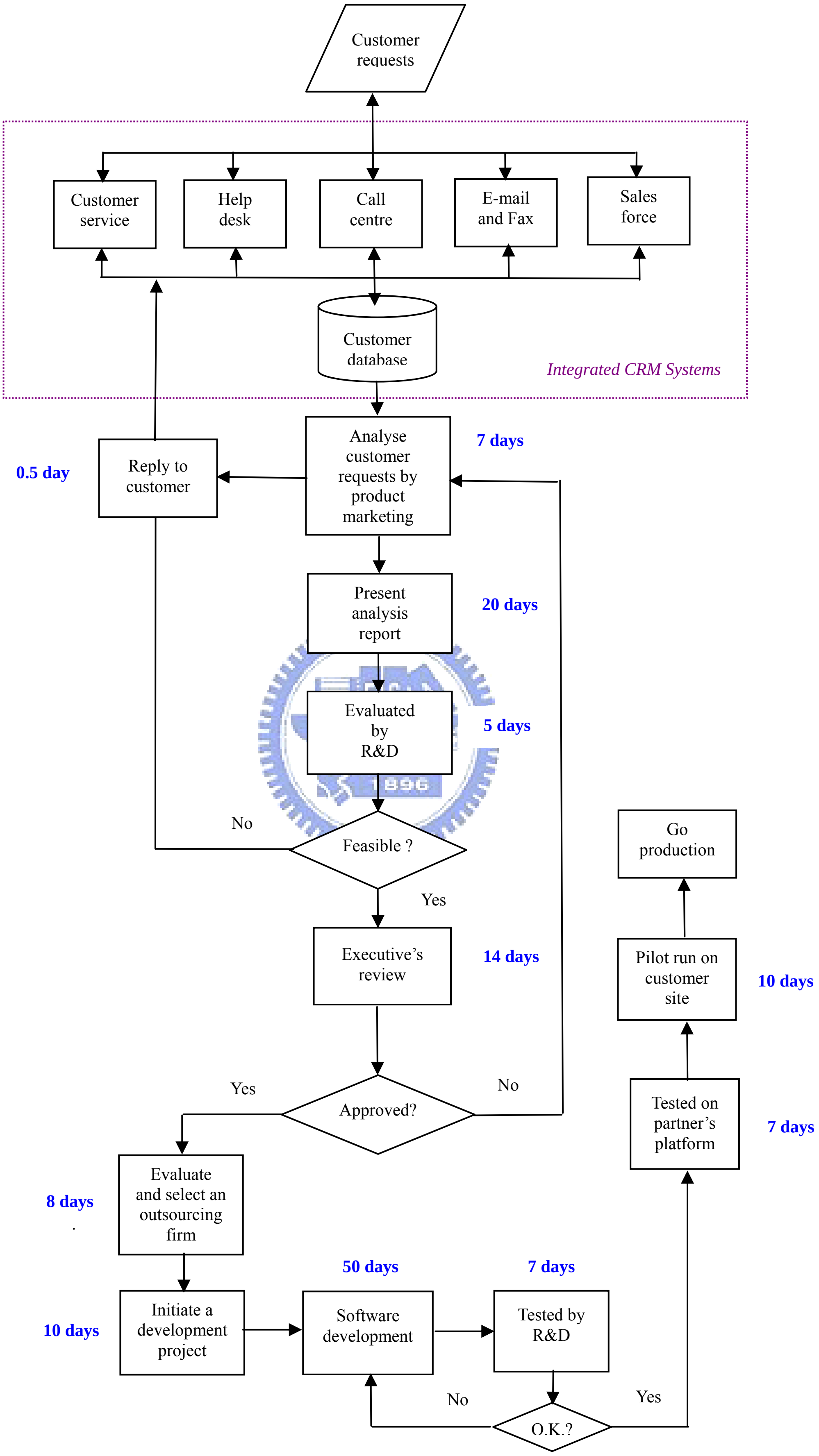

Figure 4.13 A future-state value stream map for Alternative 2 of the software development process

Phase IV: Design

Step 1: A detailed process design map is developed as shown in Table 4.17. It is noted that the input/output items in each step of the whole process are identified and established whether or not they are controllable or uncontrollable items.

Table 4.17 A detailed process design map for the software development process

Process step	VA / NVA	Input/output items	I/O	Specification levels	Controllable/ uncontrollable
Analyze customer requests by product marketing	VA	Data of customer requests	I	Complete and readable	U
	VA	Examine the data of customer requests	I	U: 3 days L: 1 day	C
	VA	Market analysis	I	U: 3 days L: 1 day	C
	VA	Economic analysis	I	U: 3 days L: 1 day	C
Present analysis report	VA	Prepare for analysis reports	I	U: 30 days L: 14 day	C
	VA	Submit analysis reports	O	N/A	C
Evaluated by R&D	VA	Analysis reports	I	N/A	C
	VA	Examine analysis reports	I	U: 2 days L: 1 day	C
	VA	Evaluate technical feasibility	I	U: 3 days L: 1 days	C
	VA	Evaluate development schedule	I	U: 3 days L: 1 day	C
	VA	Prepare for R&D comment reports	I	U: 2 days L: 1 day	C
	VA	Submit R&D comment reports	O	N/A	C
Executive's review	VA	R&D comment reports	I	With technical comments	C
	VA	Review E&D comment reports	I	U: 20 days	C
	VA	Executive meeting(s) for discussions	I	U: 14 days	C
	VA	Decision making	O	Approve or not	C
Evaluate and select an outsourcing firm	VA	A supplier list	I	N/A	C
	NVA	Search for other suppliers	I	U: 14 days L: 5 days	C
	VA	Supplier evaluation process	I	U: 7 days L: 3 days	C
	V/A	Select a supplier	O	One supplier selected	C
Initiate a development project	VA	Prepare for project plans	I	U: 7 days L: 3 days	C
	VA	Settle down the staffing, facilities, location issues	I	U: 14 days L: 7 day	C
	VA	Project kick-off	O	N/A	C
Software development process	VA	System Analysis	I	U: 12 days	C
	VA	System design	I	U: 12 days	C
	VA	Coding/debugging	I	U: 55 days	C
	VA	Source codes	O	N/A	C

Table 4.17 A detailed process design map (continued)

Process step	VA / NVA	Input/output items	I/O	Specification levels	Controllable/ uncontrollable
Tested by R&D	VA	Test on R&D's platform	I	U: 10 days L: 5 days	C
	VA	Test reports	O	U: 3 day L: 1 day	C
Tested on partner's platform	VA	R&D tested source codes	I	N/A	C
	VA	Testing	I	U: 14 days L: 7 days	U
	VA	Test reports	O	U: 2 days L: 1 day	U
Pilot run on customer site	VA	Pilot test on customer site	I	U: 14 day L: 7 days	U
	VA	Go production	O	N/A	U

Step 2: In this case, there is one non-value-added activity discovered in the detail process design map. It is the activity of searching for other suppliers and should be removed from the overall process design.

Phase V: Verify

Step 1: A pilot test of the new process design is conducted to verify the design solution. Its performances are measured and evaluated in details such that refinements might be identified to be necessary in different areas. In this particular case, the pilot result indicates the documentation of the process manual is needed to be addressed.

Step 2: Develop process control plans, which involve the use of a Check List for the internal strategic management and an R-chart for the long-term service-processing time control, so that the process owner can monitor and maintain the process.

Step 3: Since the new process design is verified and process control plans are developed, a full-scale rollout is launched next. Finally, the new process design is documented and transitioned to the process owners.

4.3.3 The implementation results and discussions

After the process redesign project was completed, the company conducted a follow-up study to examine the effectiveness of the integrated methodology. A total of 52 software development projects were randomly picked up for this 12-month study. The results of the performance metrics and the achievement of the company's goals are summarized in Tables 4.18 and 4.19 respectively.

Table 4.18 The results of the performance metrics for the software development process redesign

Performance metrics	Target		After	
	Average	Sigma level	Average	Sigma level
Cycle time for the make-or-buy decision making process	14 days	4.73	12 days	4.79
Number of the cases in which the issues of system incompatibility reported	500 DPMO	4.79	323 DPMO	4.91
Number of system defects discovered	900 DPMO	4.62	558 DPMO	4.76
Percent level of customer satisfaction with the customization	80 %	4.50	87 %	4.73
Cycle time for the software project development	92 days	4.59	83 days	4.74
Cycle time for a communication within the supply chain	5 days	4.42	3.5 days	4.58

Table 4.19 The achievement of the company's goals* for the software development process redesign

Goals	Actual (year 2004)	Target (year 2005)	Actual (year 2005)
Percent share in the Asia market of e-business solutions	9.5 %	15 %	22 %
Percent growth rate of total revenue	12 %	25 %	42 %
Percent overall profit margin	22 %	30 %	39 %

* Data was collected based on the 2006 annual report published by the company.

Based on the results as shown in Tables 4.18 and 4.19, the major findings in this follow-up study are two-fold. Firstly, all of the performance metrics achieved the target levels and the company's goals were totally realized after the integrated methodology was implemented. The successful results demonstrate that the combined approach of both DFSS and Lean is an effective strategy. Despite that the project implementation is for the particular case of software development process, the integrated methodology can be also applicable for the process design/redesign in other service industries. It is because the concepts of service quality dimensions were involved and applied in the development of the essentially integrated system. Secondly, each performance metric in Table 6 has its individual implication in relation to the subject matter of quality or speed; therefore, the achievement of a level above 4.50-sigma for all the performance metrics implies that the new process design is capable of delivering high-quality and desired services to the customer in a fast speed.

5. Conclusion and Future Research

5.1 Conclusion

This research explored the synergies resulting from the combination of the state-of-the- art quality initiatives, Lean, Six Sigma and Design for Six Sigma, and developed two integrated Lean Six Sigma and Design for Lean Six Sigma methodologies for their applications to service process improvement and design and/or redesign. For the improvement of a service process, both of the complementary strengths of Lean and Six Sigma and the shortcomings of the adoption of either system alone can provide support for the integration of the two approaches on theoretical basis. Furthermore, it was noted that the results of the case studies of both patent filing service and IT help desk service all indicated that a more stable and consistent work schedule, the reduction of overall process cycle time, and total cost savings were all substantiated and achieved. Upon reflection, these findings suggested that Lean Six Sigma approach can be a viable solution for service quality improvement since substantial benefits can be realized in terms of service quality, speed, and cost.

On the other hand, this research also investigated the benefits resulting from combining DFSS with Lean and the application of the combined approach to the critical design stage of service processes. The rationale for developing an integrated methodology is elucidated and used as a justification for the appropriateness of the approach. In addition, since the essentials of service quality dimensions are considered and involved in the development of the methodology, therefore it is a logical statement that the integrated system is built specifically for the service application. Meanwhile, in view of the case study of software development process, the considerable benefits obtained from implementing the methodology are substantiated. The empirical results not only provide evidence for demonstrating the efficacy of the mixed strategy, but also highlight the competence of the methodology.

5.2 Future research

Finally, to suggest the future study of leveraging the advantages of both Lean with Six Sigma or Lean with DFSS, there are some potential areas that deserve to investigate. For instance, the sustainability of the implementation results for both integrated methodologies was not discussed in this research, and thus it deserves to be explored in the future. Next, the people issue had not been dealt with during this research process, that is, the concern of change management in an organization was not emphasized, and therefore it can become a topic for further study. Recently, improving or designing and/or redesigning marketing processes through the approach of either Lean Six Sigma or Design for Lean Six Sigma has been emerging topics in both the academic and practical fields. It might be another success in the marketing arena following manufacturing and service.

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