

**A FRAMEWORK FOR DEPLOYMENT OF  
PROCESS IMPROVEMENT FOR  
MANUFACTURING INDUSTRY**

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**A FRAMEWORK FOR DEPLOYMENT OF PROCESS IMPROVEMENT  
FOR MANUFACTURING INDUSTRY**

**By**

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# **SATU RANGKA UNTUK PENGGUNAAN PENAMBAHBAIKAN PROSES TERHADAP INDUSTRI PEMBUATAN**

## **ABSTRAK**

Disebabkan persaingan pasaran yang meningkat dan penurunan harga yang dituntut oleh pelanggan setiap tahun, banyak syarikat dalam industri pembuatan perlu memulakan penambahbaikan proses. Sesungguhnya, pelaksanaan penambahbaikan proses dalam industri pembuatan akan meningkatkan kecekapan proses sedia ada dan menghasilkan keuntungan yang besar kepada syarikat. Malangnya, disebabkan kekurangan ilmu pengetahuan dan ketidakupayaan menjalankan penambahbaikan proses, banyak syarikat gagal untuk mendapat sebarang faedah daripada penambahbaikan proses mereka. Dengan itu, pelaksana, khususnya pelaksana baru, memerlukan bimbingan supaya mereka dapat menjalankan penambahbaikan proses dengan berkesan. Oleh itu, satu rangka kerja baru yang dinamakan DRIES [Mentakrif, Menyemak, Mengenal pasti, Melaksanakan, dan Bertahan] telah dibangunkan dalam penyelidikan ini. Untuk tujuan ini, sorotan karya telah dibuat dan diklasifikasikan sebagai elemen yang penting dalam rangka penambahbaikan ini. Butiran dan teknik-teknik penambahbaikan bagi setiap tahap rangka kerja juga dimasukkan dalam kajian ini. Selain itu, rangka kerja yang dibangunkan ini telah dipraktikkan di dua buah syarikat semikonduktor dan pemesinan di Malaysia. Rangka kerja ini telah berjaya diaplikasikan di kedua-dua buah syarikat dan mencapai keputusan yang diinginkan. Pencapaian itu membuktikan pembangunan rangka kerja DRIES dan menunjukkan bahawa rangka penambahbaikan ini mempunyai keupayaan dari aspek sistematik, kebolegunaan, kebolehubahan, dan kecekapan. Pengajaran yang diperoleh daripada kedua-dua kes kajian ini telah dihuraikan supaya ia dapat dijadikan garis panduan untuk mengelakkan kesilapan

yang sama dilakukan oleh pelaksana pada masa hadapan. Secara ringkasnya, sumbangan utama penyelidikan ini ialah cadangan satu rangka kerja penambahbaikan proses dengan menggabungkan unsur-unsur utama yang penting dan parameter-parameter reka bentuk rangka kerja, dengan tujuan utamanya ialah membantu pelaksana menjalankan penambahbaikan proses dengan cara yang lebih mendatangkan kejayaan.

# **A FRAMEWORK FOR DEPLOYMENT OF PROCESS IMPROVEMENT FOR MANUFACTURING INDUSTRY**

## **ABSTRACT**

Owing to growing competitiveness in the market and year-on-year price reduction that is highly demanded by consumers, many companies in manufacturing industry have to embark on process improvement. The implementation of process improvement in manufacturing industry will improve the efficiency of existing operation process and yield high profit to the company. However, due to lack of knowledge and capability to perform process improvement, many companies fail to gain the maximum benefit from their own process improvement. Therefore, to ensure the implementer especially new practitioner can effectively embark in the process improvement, a new framework named DRIES (Define, Review, Identify, Execute, and Sustain) is developed in this research. For achieving this purpose, relevant literature has been reviewed and identified as the key elements of the process improvement framework. The details and improvement techniques of each stage of the framework are also highlighted in this study. Besides, the developed framework had been examined in the semiconductor and machining companies in Malaysia. Eventually, this framework had successfully achieved the desired results in both companies. The achievement also further assure the capability in terms of systematic, practicality, flexibility, and efficiency of the DRIES framework. The findings of the two case studies were discussed in the study in order to serve as a guideline for preventing the implementers from committing the common and identical mistakes. With the implementation of the newly developed process improvement framework

integrating with the fundamental key elements and framework design parameters, it is expected that the implementers are able to perform process improvement in a more successful manner.

# CHAPTER 1

## INTRODUCTION

### 1.0 Overview

This chapter is divided into five sections. The first section gives an overview of this research background. The research problem statement is discussed in section two. The next following section discusses on the research objectives. The fourth section deals with the research scope and the last section presenting on the thesis layout.

### 1.1 Background

In the dynamic and competitive industrial arena, organisations are facing with highly competitive market due to the rapid change of global market conditions. The demand for lower prices and better quality products will erode the profit margins. Today, Malaysia is no longer considered a low cost workforce country in South East Asia region as it has shown a steady decline in manufacturing job opportunities. Manufacturing facilities in Malaysia have scaled down in size and the same scenario is happening to other local industrial sectors, which have also opted to move out to countries offering lower labour cost. This factor underscores the important of Malaysian organisations to keep improving their qualities in order to enhance their competitiveness.

An organisation with a strong continuous process of improvement is more likely to survive and grow. Process improvement is considered as a method of improving the organization of an existing process activity in systematic manner.

Improving the operation will produce a more efficient process that will result in higher productivity, better quality and higher profitability. However, too few of these process improvements are successful and this is supported by Hammer and Champy (1993), which states that 70% of process improvements are less than successful. The question is: “Why is the failure rate high?” One of the reasons is the lack of understanding and the inability to perform process improvement [Chan & Choi (1997) and Yahya (2002)]. These bring up the question: “How to increase the understanding and the ability to perform process improvement?” The answer lies in finding a medium to provide the implementer all necessary guidance as much as possible. The medium must assist the implementer in a systematic way and effectively implements the process improvement from commencement until project completion.

What is the medium stand for? The answer is a framework which is to incorporate all necessary methodology, guidance, and tools that provide knowledge support to the implementer in performing improvement. The framework provides an overview of the implementation and a more detailed description of each framework’s element in order to introduce the elements and implement activities in a more systematic, comprehensive, controlled and timely manner.

## **1.2 Problem Statement**

A systematic sequence is needed in process improvement to achieve the improvement goal. After completing one-step of process improvement, most implementers especially new practitioners will ask “What the next step is and fail to find the answer (Rohleder & Silver, 1997). In other words, the implementers need to have guidance when performing the process improvement. However, the question is: What is the guidance and how to create the guidance?

The second problem is that most of the implementers do not have an in-depth knowledge and skills in analyzing and managing the improvement process. They tend to carry out the improvement project based on their past working experience (Lee & Chuah, 2001). Due to the difficulty to perform based on their experience, this will indirectly cause the organization to be too dependent on certain employees, which may affect the organization performance if these people resign. Hence, the organization needs to continuously pick up new practitioners. However, most organizations often find it very difficult to upgrade their staff in knowledge in a short time period. This leads to the next question: “How to improve the new practitioners’ knowledge in short period?”

Because of the time and cost constraint, most companies cannot afford to send all their engineers and technicians to attend formal seminars to enhance the knowledge of process improvement. The seminars only provide the experienced lecturers for presenting the solving tools and knowledge needed in process improvement. For that purpose, a well developed process improvement framework is crucial in transferring as much as possible the knowledge to the implementers.

In addition, very few researchers discuss and concern about how to develop the process improvement framework and what are the criteria that need to be considered in order to develop a good framework. Most of the published framework are polished that only completed appearance of the framework are shared and the rest of the information is kept for internal assessment.

Therefore, as an initial effort towards filling this gap and overcoming the stated problems, a framework is developed in this research as a process improvement guidance tool to increase the success rate of project improvement.

### **1.3 Research Objectives**

The objective of this research is to develop a framework to guide the implementers carrying out the process improvement activities. The framework must consist all the necessary and important elements to increase the success rate of process improvement. It is hoped that the developed framework can be fully utilised by the users through the guidance and help them to gain the highest benefit of implementation as well as decrease the failure rate of process improvement.

Modelling approach is chosen in this research through benchmarking the available improvement frameworks and incorporates the key elements from the reviewed frameworks. Since the framework is developed through benchmarking various frameworks, it aims to develop a more superior with several appropriate parameters to establish a process improvement framework.

It is hope that the findings from the case study in real industries will serve as the revelation and reference to who wants to implement the process improvement.

The objectives of this research are shown as follows:

1. To review and indentify the key elements from the frameworks available in the market;
2. To identify and propose the most appropriate parameters as the benchmark for developing the process improvement framework;
3. To develop a process improvement framework that covers the aspects of process improvement methodology and framework design parameters; and
4. To pilot and validate implementation of the developed framework in two selected companies in Malaysia for conducting the case studies.



## **1.4 Scope of Research**

Since the developed framework is for industrial application, the validation of the framework should be done practically. Thus, the scope of this research is two case studies using the developed framework to conduct the process improvement initiative. In order to prove the flexibility of the framework, two case studies are done with different company background. Each case study consumes 12 weeks of duration. On the other hand, the new practitioner will be included as implementer in the case studies validations. This is because one of the missions in this research is to support the new practitioners for implementing the process improvement. Therefore, the capability and successfulness of the developed framework can be verified.

## **1.5 Layout of Thesis**

The thesis is divided into six chapters. Chapter 1 provides an overview of current issues and problems faced in process improvement implementation, research objective, and scope of research. Chapter 2 covers the detailed literature review, which corresponds to the background theories adopted in the research. The following chapter presents the systematic methodology of framework development. Chapter 4 focuses on case study validation, which the developed framework will be validated in two selected companies in Malaysia. The overall discussion and lessons learned from the case study validation will be discussed in Chapter 5. Finally, chapter 6 summarises the important findings and concludes the research. Recommendation for future research is also presented in this chapter.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Overview**

This chapter explores and summarises related literature on process improvement implementation. It provides the basis for designing and developing the research instruments and performing final analysis. This chapter is divided into six sections. The first three sections review the process improvement including overview, performance measure and its pitfalls. The definition, reasons and design requirements of the process improvement framework are discussed in the fourth section. The fifth section examines previous studies on the process improvement frameworks as the foundation prior to the new proposed conceptual framework in chapter three. Findings from the literature review will then be discussed at the end of this chapter.

#### **2.1 Process Improvement Overview**

Process improvement is a series of actions taken by an implementer to identify, analyse and improve the existing processes within an organisation to ensure the process is implemented as efficient as possible in order to meet the new goals (Cook, 1998). In other words, the major aim of process improvement is to bring the company to becoming a high efficiency company. Different authors have given a diversity of definitions of process improvement. There are many different terms relating to the improvement of processes such as Business process redesign (Davenport & Short, 1990; Tinnila, 1995), Continuous process improvement (Jorgensen et al, 2004), Business restructuring (Lee & Lin, 2008), as well as business

process re-engineering (Abdolvand et al., 2008; Zairi & Sinclair, 1995). These concepts relate to a range of activities from the process of implementing improvement to the complete restructuring of organisations. The term and definition of process improvement are different but the approach and the aim are similar, which is to improve the existing process to become better (Povey, 1998). The similarities amongst the above scholars can be observed in various definitions of process improvement discussed in the literature:

...the fundamental rethinking and radical redesign of business processes in order to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed (Hammer & Champy, 1993; Zairi & Sinclair, 1995).

...the analysis and design of processes are carried out within and between organizations (Davenport & Short, 1990).

...to rethink, restructure and streamline the business processes and methodology of working and management systems through which improving the operating performance (Lee & Lin, 2008).

...as a process planned, organize and continuous incremental improvement and innovation practices in order to satisfy customer requirements, competitiveness and effectiveness of a whole organization [Harrington, 1991; Jorgensen et al., 2003).

...as a problem solving for quality improvement in order to meet customer requirement (Kanji & Asher, 1996).

According to Muthiah and Huang (2006), through the survey of 967 companies, the results indicate that 95% of companies have conducted process improvement. However, Hammer and Champy (1993) found that 70% of the

companies failed to achieve any benefit from their own process improvement efforts. With so many improvement efforts ending with failure, one may wonder why companies ever make their efforts. There are several reasons why the companies need to perform process improvement. The main reason is that when improvement efforts do succeed, the company can have significant economic gain. Process improvement benefits to the company on increasing profit margin through eliminating or reducing the non-value added activities; for example, the Global Integrated Circuit Corp improved the problem of IC de-lamination, which had helped the company to save \$1.25 million annually and reduced customer dissatisfaction (Su et al., 2005). Desai and Shrivastava (2008) helped a manufacturing enterprise to improve the welding process, which leading to 93% of increasing process yield and the improvement saved the company over \$30000 annually.

## **2.2 The failure of process improvement**

As discussed earlier, process improvement helps many companies to improve their competitiveness and increase the profit. These success stories can be found in many cases. Although there are many successful implementation of process improvement, many failures have also been faced. These failures may be caused by several problems. According to Kanji and Barker (1990), the management causes 85% of the problems in implementing process improvement and the remaining 15% are due to operation and technology problems.

There are different reasons for encountering failure in conducting process improvement. Some reported causes of failure attribute to the inability to perform process improvement such as the follows:

- Lack of an effective methodology: Process improvement requires a new method of thinking breaking out of the old method to develop vision (Chan & Choi, 1997; Klein, 1994; Yahya, 2002).
- Wrong process and objectives: The implementer may select the wrong process for improvement, which does not impose greater value to the situation after improvement, or a process that is not the bottleneck of operations. Therefore, there may not be dramatic improvements (Mathews, 1995; Chan & Choi, 1997)
- Lack of recognition of the benefits gained: unclear and inadequate vision of the benefits such as tangible and intangible benefits gained from improvement efforts (Chan & Choi, 1997; Rai & Paper, 1994).
- Lack of top management commitment: Top management requires commitment in order to adopt the change and direct of shifting and improve the operation (Baines, 1997; Klein, 1994; Radovilsky. et al., 1996).
- Unwilling and unreceptive workforce to change: Low motivation, poor quality performance, distrust and high absenteeism (Baines, 1997) results in a resistance to change.

Chan & Choi (1997) also listed several reasons of failure of process improvement and they found that lack of methodology for process improvement and analytical framework are the major issues related to process improvement. They believe that failures can be reduced or avoided if there are frameworks to guide the implementer to perform process improvement. Meanwhile, Holbeche (2005) stressed that the company must be able to create a balance between performance, quality, customer relations and profitability in order to reduce the failure of process

improvement. One may say that process improvement is a dynamic approach that involves empowerment of people and correct approaches in order to reduce the failure of process improvement efforts.

## **2.3 Process improvement framework**

### **2.3.1 Definition of framework**

A framework in general is a description of a process, which is usually in a simplified form. According to Yusof and Aspinwall (2000a), there is no consensus on the definition of the frameworks. Different writers have different set of definition, use or ideas used of framework. Some writers have referred to it as being a prescriptive set of things to do. The others have described the framework through diagrams, flowcharts and graphical or pictorial representations.

After reviewing several examples of frameworks and models, Rouse and Putterill (2003) found that both of them have their own strength and functionality. They classified frameworks to be useful ways of providing prescriptive and direction for the user for guiding purposes; models are more towards system representation that allows for prediction and investigation of the system properties. This is supported by Young (2003), which a model to engineer is normally referred as an abstraction that involves an explicit mathematical formalism of the process being studied. On the other hand, Yusof and Aspinwall (2000a) have a different view that a model answers the question “What is...”, with the overall concept and elements put down together; whereas a framework answers “How to...” questions and provides an overall way forward to the goal.

Popper (1994) as quoted by Deros et al. (2000) defined a framework as a set of basic fundamental principles that can help to promote discussions and actions.

Meanwhile, Dale (1995) defined a framework as a means of presenting plan and concepts. A framework allows the user to choose an appropriate starting point, course of action and develop the individual elements of process improvement at a pace that fits the organisation environment.

In short, it can be concluded that the term “framework” is a structure for driving, or proposing something as a basic arrangement toward the goal of the project. Recently, research dealing with framework has grown drastically with a lot of efforts that have been developed for process improvement of company operations in a variety of industrial areas (Lee and Chuah, 2001; Fleischer, 2003)

### **2.3.2 The reasons of establishing a framework**

Framework is the tool that is able to reduce the failure and drive the process improvement. According to Rohledher and Silver (1997), many organisations have the enthusiasm and motivation in process improvement, but it loses when fighting their way through all the associated tools and techniques. They found that everyone in the process improvement team and management always asks “What do we do next?” and no one often has the answer. In doing so, the authors emphasise that the use of a conceptual framework for working through the steps of process improvement is necessary in order to have a systematic and effective process improvement. However, they also stated that framework is meant only as a guideline and not necessarily designating the sequence of the steps and rigidly followed. They mentioned that creativity is an important component of process improvement and rigid guidelines tend to stifle creativity.

The importance of using framework in process improvement has also been agreed by many researchers. For instance, Davies and Kochhar (2000) found that adoption of the best process improvement practice is not sufficient to emulate the

success of improvement. This is because the practices have to be adapted to the environment which the company is operating. Therefore, they agree that any process improvement practices need to be adapted to the structure framework in order to have perfect result. Motwani et al. (1998) states that the most important step in process improvement is to plan for improvement. The author suggested creating a comprehensive framework for improvement, defining responsibilities and appointing an improvement plan from the beginning to implementation are the fundamental of improvement.

By deeply reviewing the operational management practices such as TQM, BPR, reengineering, etc, Grunberg (2004) found that none of these operational management practices is particularly adapted in identifying what to improve and do not provide working method for the user to perform the improvement project. These statements are also supported by Deros et.al (2000), which the most frequent reason of the failure of these operational management practices is due to wrong implementation. They stressed that a framework is needed in order to reduce the failure. Aalbrecht et al (1991); Deros et al. (2000); Mishra et al (2007) also list down several reasons for having a framework. They are as follows:

- 1) Illustrate an overview and communicate a new vision to the organisation;
- 2) Force management to address a substantial list of key issues which otherwise might not be addressed;
- 3) Give valuable insights into the organisation's strengths and weaknesses, and its overall strategic position in the market-place;
- 4) Support implementation and to improve the chance of success because it will provide not only overview but also more detailed information describing the content of each framework element and its relationship to other elements; and



- 5) Able to guide the organization in implementing activities in a more systematic, comprehensive, controlled and timely manner.

In short, the first thing should be done before initiating on process improvement is to develop a framework. The framework will make the organisation or implementer getting more awareness of process improvement and be able to introduce its elements and features in a more systematic and compatible manner.

### **2.3.3 Framework design requirements**

In general, process improvement framework is normally carried out with the purpose to show clear picture of the way to carry the process toward the project goals. In order to support the implementation, the framework must consist not only an overview but also more detailed and clear information describing the content of each framework element and the relationship between elements (Aalbrektse et al., 1991; Rouse & Putterill, 2003). On the other hand, Struebing and Klaus (1997) mention that a good framework should define how it is going to do it and ensure that each step is done in the systematic and correct sequence. In other words, a good framework must be able to provide the steps to guide the user on how to achieve and complete the stage when implementing the process improvement.

According to Mishra et al. (2007), the developed framework should fulfil “more generic in nature and not dependent on the operation environment”. The applicability of developed framework is not constrained by the size of company, sectors industries and resource available. However, Yusof and Aspinwall (2000b) believe that most of the frameworks published in the literature have not considered for applicability in small organisation, as the organisation lacks technical expertise

and human resources in implementing process improvement. The authors also state that too complicated framework is not well suited to small organisation.

Other than that, Khan et al. (2007) implemented the survey/interview analysis on the implementation process of the process improvement framework. From the analysis, it was concluded that a new process improvement framework is needed to overcome the limitation of current frameworks, which are either academic or large company oriented and it should have the following seven main outcomes: (1) show quick initial results; (2) take into consideration the resource implication; (3) must utilise the company strength; (4) can be implemented at pace that suits the user; (5) Implementation of the framework will eventually lead to the company becoming world class; (6) create a culture of continuous change and hence, make continuous improvement a norm; and (7) The framework must be simple and practical and not overtly academic due to concern shown by management of collaborating companies. Apart from them, Yusof and Aspinwall (2000a) and Deros et al. (2000) also list down several criteria in developing a good framework such as: (1) systematic and easily understood; (2) simple in structure; (3) having clear links between the elements or steps; (4) general enough to suit different contexts; (5) represent a road map and a planning tools for implementation; and (6) answers “how to?” and not “what is?”.

In conclusion, there are four basic requirements that must be fulfilled in order to design a good framework, such as:

- 1) Simple and easily understood;
- 2) Having clear links between the steps;
- 3) General enough to suit different contexts;
- 4) Answer how it is going to do it (Answers “how to?” and not “what is?”]

## **2.4. Review of process improvement framework**

In this section, several studies on the relevant process improvement framework are reviewed, which includes various frameworks proposed and developed by different organisations, consultants and researchers. The reviewed frameworks are categorised into two types such as practical-based framework and theoretical-based framework.

### **2.4.1. Practical based Framework**

Practical-based frameworks are derived from personal interpretation through practical improvement experience in providing consultant action service to organisations implementing an improvement project. On the other hand, the framework are also categorised as practical-based framework if the developed framework has been validated by case study approach (hands-on), which has proved the practicality of the framework. In other words, the practical-based framework implementation is more real world oriented.

#### **2.4.1.1. Boeing's Continuous Process Improvement Framework**

The Boeing's continuous process improvement framework (Shanks, 2001) is developed by Boeing Company to implement Lean initiative to improve the manufacturing process as shown in Figure 2.2.

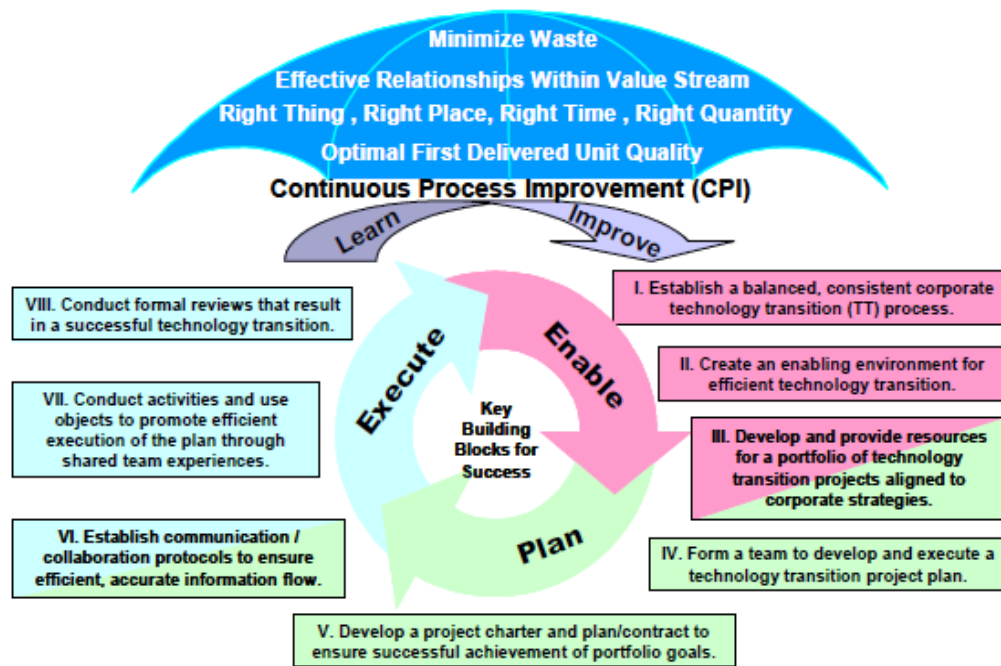


Figure 2.1: Boeing's Improvement Framework (Shanks, 2001)

This framework consists of three phases-Enable, Plan and Execution, and forms a closed loop improvement cycle driven by eight major steps. Each phase has its functionality and major in efficiency improvement that can be achieved by application of selected phases to single steps or part of the steps. The advantages of this framework are: (1) simple and easily understood; (2) having clear links between the steps; and (3) able to suit different context of process. Nevertheless, the framework is unable to fulfil “answer how is going to do it” requirement, which the framework do not provide sufficient information to user in the way to complete the stage.

#### 2.4.1.2. Lia and Zuo (1999) Process Improvement Framework

Lia and Zuo (1999) provide a practical guide in implementing process improvement in the semiconductor industries based on their consultant's experience. The framework is divided into four steps, namely process decomposition, structured fault tree, qualitative evaluation and experiment assessment as shown in Figure 2.3.

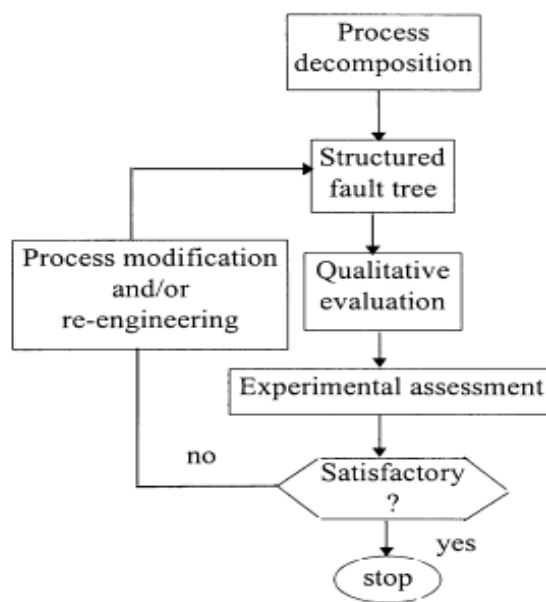


Figure 2.2: Lia and Zuo (1999) Improvement Framework (Lia and Zuo, 1999)

The authors suggested to create a structure framework that is fundamental in process improvement. The framework mainly analyses the process and access the root causes. The framework is simple and it can be used in any improvement areas. Nevertheless, the framework lacks of some detailed steps and the description of framework's elements is too general, which is unable to assist the user especially new practitioner. Thus, this framework does not fulfil "answer how it is going to do it" from the framework design requirement perspective.

### 2.4.1.3. PDCA Process Improvement Framework

The PDCA known as plan, do, check, act is developed by Walter Shewhart (Konz & Johnson, 2001; Smadi, 2009) as shown in Figure 2.4.

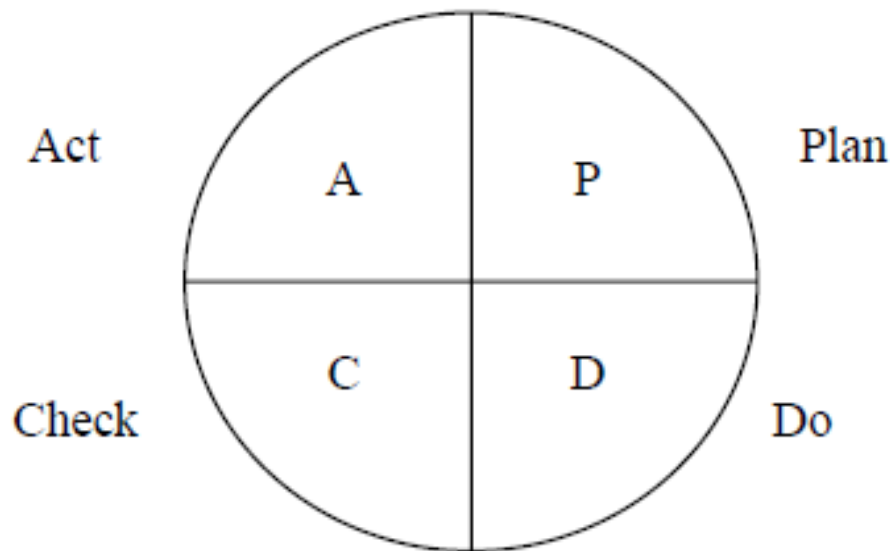


Figure 2.3: PDCA Improvement Framework (Smadi, 2009)

The PDCA is a continuous feedback loop with four phases of iterative approach such as plan, do, check and act. The framework is commonly used to define and develop a new improvement project for a product or process that involves a repetitive work process. The framework mainly provides the general phase outline and allows the user to add appropriate steps into each phase. The advantages of the PDCA framework are: (1) simple and easily understood; (2) having clear links between the steps; and (3) general enough to suit different context. As the framework does not provide any supporting elements information; thus, it is often difficult to accomplish on-going process improvement. The framework assumes the users possess full knowledge on the process improvement and PDCA methodologies; however, only a handful of implementers have in-depth experience of PDCA improvement process and even lesser practice especially for new practitioner on a consistent basis. In

addition, the framework has less emphasis on definition and analysis activities before executing an improvement project and more emphasis to the activities after execution stage.

#### 2.4.1.4. SUPER Process Improvement Framework

Lee and Chuah (2001) develop a process improvement framework, namely SUPER framework as depicted in Figure 2.5.

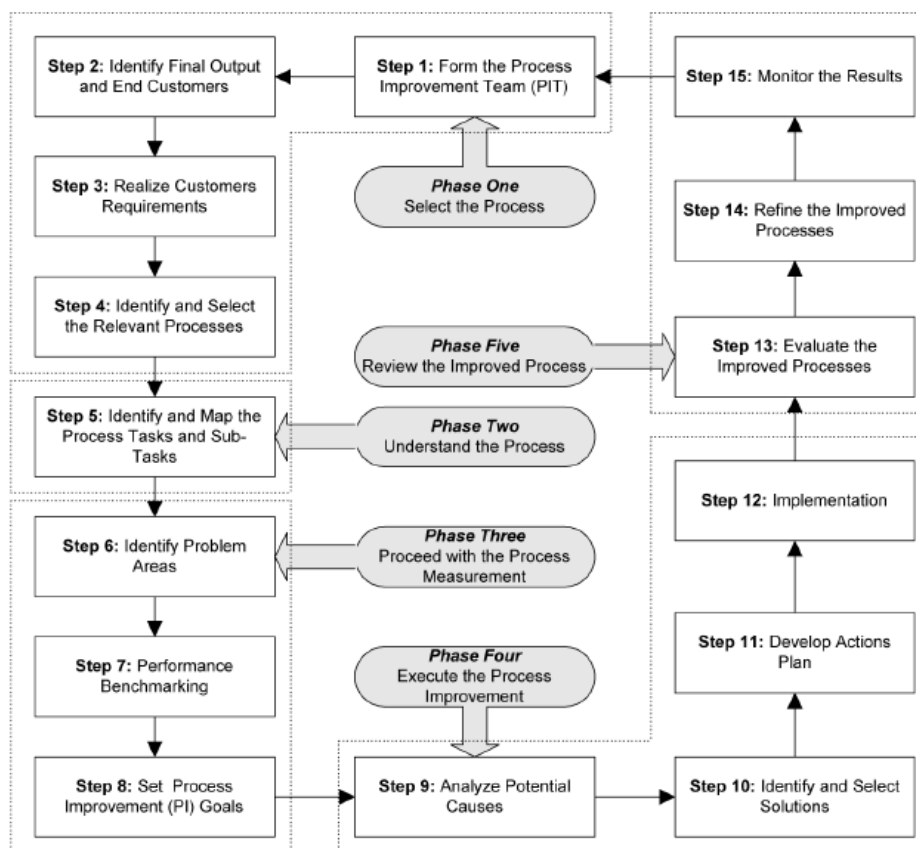


Figure 2.4: SUPER Improvement Framework (Lee & Chuah, 2001)

The SUPER is an acronym for: select the process; understand the process; proceed with the process measurement; execute the process improvement; and review the improved process. The SUPER framework is a three-in-one approach, which integrates the key elements of the business process re-engineering (BPR), continuous process improvement (CPI) and benchmarking improvement methodology. The

framework is used to tackle the improvement problems, which arise in an organisation with the primary aim to achieve significant improvement in operations. The framework fulfils all the framework design requirements such as: (1) simple and easily understood; (2) clear links between the steps; (3) able to suit different context of process; and (4) Answer how it is going to do it. However, it is recommended that the solution tools and succeed parameter of each stage should be added into the framework in order to enrich the confidence of user when using the framework.

#### **2.4.1.5. Dale (1994) Process Improvement Framework**

Dale (1994) develops a framework based on conference with two groups of small and large companies. He developed two frameworks- one catering the needs of small company and one for larger company. The author clarifies the importance of organising the process and changing the culture in organisation in order to position the improvement practices. The frameworks are organised in sentences by using the questioning method to guide the user. The framework of small company can be summarised into seven steps, they are: (1) long term strategy, (2) quality definition, (3) sources of advice, (4) approach to process improvement, (5) stages of improvement activity, (6) executive leadership, and (7) a training cycle. On the other hand, the large company framework has consisted 16 steps, namely: (1) formulate company vision; (2) define company's quality objective; (3) formulate strategy; (4) prepare quality improvement plan; (5) formulate teams; (6) leadership/commitment/visual signs, (7) training/education, (8) supplier/customer relationship, (9) information, (10) communication, (11) organization/ re-organization, (12) advice, (13) allocate appropriate resources, (14) encouragement, (15) flexibility, and (16) culture. The author suggests that the characteristic and



background of the organizations need to be considered when developing a framework. The questioning method successfully reflects the user's awareness and alert on the tasks needed to be done. Hence, the method indirectly assists the user on the way to complete the stage. Nonetheless, these frameworks are presented in sentences and confusing way. Both frameworks do not show clear links between the steps.

#### 2.4.1.6. NPC (1990) Process Improvement Framework

NPC (1990) develops an improvement framework. The adaptation of framework is generated from the recommendations of best practices in companies. The process improvement framework is divided into three phases as illustrated in Figure 2.6.

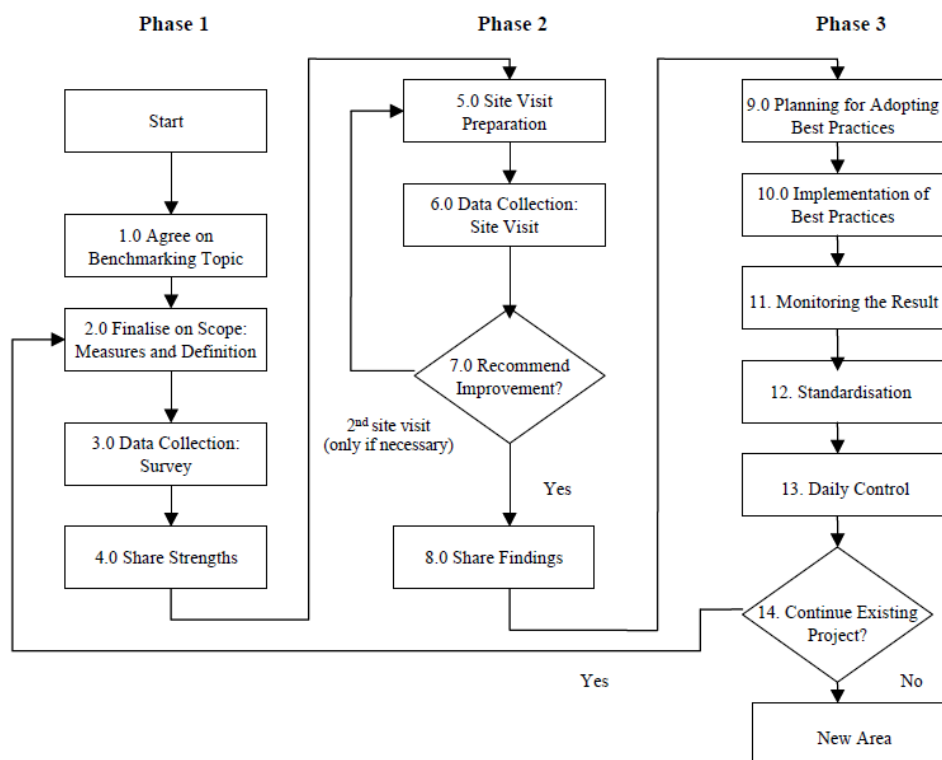


Figure 2.5: NPC (1990) Improvement Framework (NPC, 1990)

The first and second phases mainly focus on benchmarking process while finding the solution, execution and sustain the implementation are emphasised in third phase.

The three-phase approach is used to define the improvement problems and serves as a road map to move a process from its current state along guide path to better performance. The advantages of this framework are: (1) provides useful systematic step for assessing, measuring and evaluating the progress made; (2) simple and easily understood; (3) have a clear link between the steps; and (4) enable to suit any improvement process. Yet, the elements of framework do not organised well according to respected outlines and they are unable to assist the user in the way to implement it.

#### 2.4.1.7. DMAIC Process Improvement Framework

DMAIC framework is one of the Six Sigma tools used to improve existing processes by continuous reviewing and refining the processes. The framework provided by Gupta (2005) is shown in Figure 2.7.

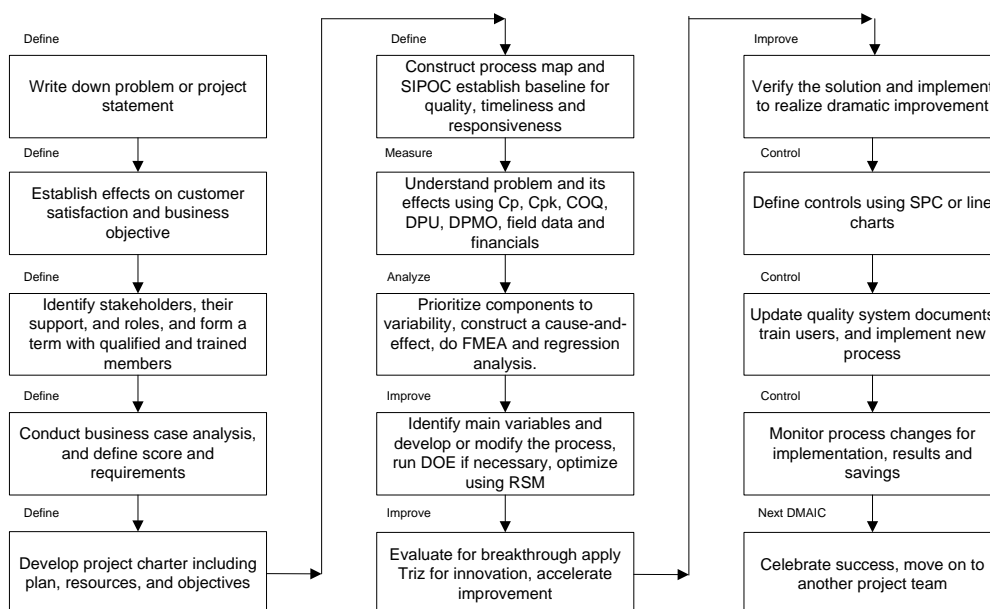


Figure 2.6: DMAIC Improvement Framework (Gupta, 2005)

The DMAIC is the short term for define, measure, analyze, improve, and control.

The DMAIC framework starts with writing a clear problem summary. The

customer's input is considered in understanding the effects and scope of the problems. A selected solving tool for DMAIC is depending by taskforce, which lead elected on taskforce status is either black belt or green belt. The strengths of framework are: 1) simple and easily understood; (2) clear link between the steps; (3) general enough to suit different contexts; and (4) Answer how to going to do it. Besides, the framework adopts several tools and methodology to assist the user. However, the elements and tools recommended by this framework emphasises more on dimension of quality improvement.

#### **2.4.1.8. Carpinetti et al (2000) Process Improvement Framework**

Carpinetti et al (2000) present a conceptual framework for managing the process by deriving improvement actions from customer expectations. The framework consists of nine stages: (1) develop improvement team; (2) understand the product and market; (3) identify critical dimensions for improvement such as customer expectations; (4) identify critical processes for improvement; (5) implement performance assessment to identify the weak points; (6) devise dimensions and processes for improvement; (7) implement actions; (8) critical measures; and (9) feedback and review of progress. Guidelines are provided on how to perform process improvement such as identify the competitive dimension; deploying improvement project from strategic decisions and customer perspective; and prioritising the most impact performance on dimension. The advantages of framework are: (1) simple and easily understood; (2) having clear links between the steps; and (3) general enough to suit different context. However, the framework is organised in sentences, which is unable to describe the framework elements and flow patterns in clearly manner to the user.

### 2.4.1.9. Raytheon's three phase process improvement

The Raytheon's three-phase process improvement framework is developed by Raytheon in accordance with the principles of W. Edwards Deming and Joseph Juran as illustrated in Figure 2.8 (Dion, 1993).

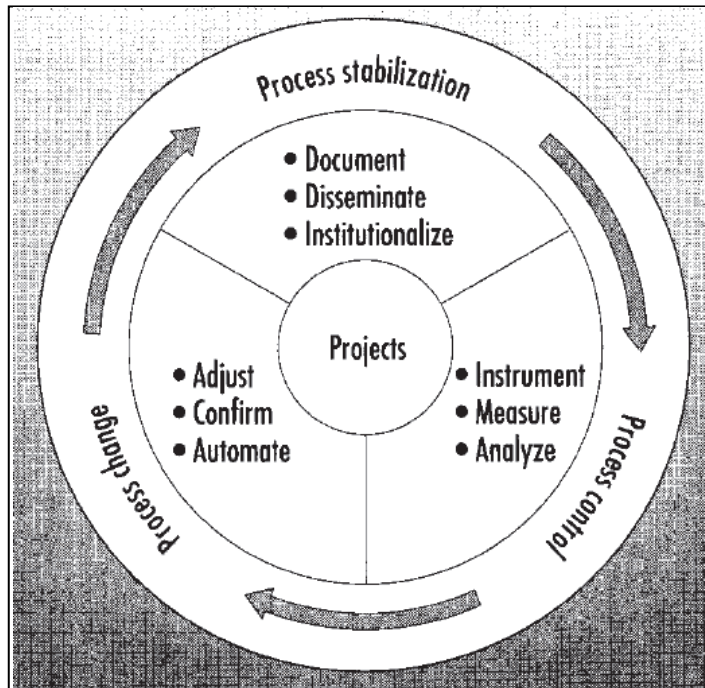


Figure 2.7: Raytheon's three phase Improvement Framework (Dion, 1993)

The core objective of the improvement framework is the continuous improvement of the development and management processes. The author emphasises that real process improvement must follow a sequence of steps, starting with making the process visible followed by repeatable and then measurable. The Raytheon framework is a closed loop improvement, which consists of process stabilization, process control, and process change. In the process-stabilization phase, the emphasis is on distilling the elements of the process to achieve high visibility and intensively institutionalising it across all projects. In the process-control phase, the emphasis shifts to executing projects to gather significant data and analysing the data to

understand how to control the process. In the process-change phase, the emphasis is on determining how to adjust the process based on the result of measurement and analysis on earlier stages. The advantages of the Raytheon's framework lies in simple and clear links between the steps and general use. Nevertheless, the framework is offered in general term. It provides inadequate guidance to assist the user on the way of performing process improvement.

#### 2.4.1.10. Raytheon Six Sigma Process Improvement framework

Raytheon Six Sigma Improvement framework is developed by Daniel Burnham based on the Six Sigma framework as represented in Figure 2.9 (Fleischer, 2003).



Figure 2.8: Raytheon Six Sigma Improvement Framework (Fleischer, 2003)

The Raytheon Six Sigma Improvement Framework consists of six phases such as visualized, commit, prioritize, characterize, improve and achieve. The framework is a knowledge-based process that is used to transform the culture of a company in order to maximise value to customer. The tenets of Raytheon Six Sigma are the same as "Lean" which are: (1) specific value in the eyes of the customers; (2) identify value stream; (3) simplify the steps and eliminate waste and variation along the value