NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

A Case Study of Using Six-Sigma (DMAIC) Methodology in Manufacturing Industry

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May 2006

KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: A CASE STUDY OF USING SIX-SIGMA (DMAIC) METHODOLOGY IN MANUFACTURING INDUSTRY

SESI PENGAJIAN: 2005/2006

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I hereby, declare this thesis entitled "A Case Study of Using Six-Sigma (DMAIC) Methodology in Manufacturing Industry" is the results of my own research except as cited in the reference.

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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process). The members of the supervisoring committee are as follows:

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DEDICATION

I would like dedicate this thesis to my beloved parents and my family

ACKNOWLEDGEMENTS

The name of Allah, most gracious, most merciful.....

Alhamdulillah, it same like something impossible for me after complete my thesis where it take almost 8 months to make it real. To complete my thesis actually incriminate many party such as engineer from FLEXTRONICS TECHNOLOGY (M) SDN BHD, lecture from Faculty of Manufacturing Engineering and also my Supervisor and here I would like to dedicate thank you so much to all was given teach, co-operation, enthusiastic support in to ensure my thesis are success without any problem.

I also would like to thanks to Faculty of Manufacturing Engineering, KUTKM especially to Prof. Madya Dr. ir Adi Saftari for spent their time and give full effort to support and give representation as valuable guide to me while make this thesis at Flextronics and also to all lectures. Without theory and guide from all with is impossible for me to complete this thesis.

I also would like to thanks to Flextronics training department Miss Anuratha, Head of Manufacturing Department Mr Philip Naik, and also for my Senior Manufacturing Engineer, Mr Neezad Fazwal was be my team member during complete this thesis, engineer, technician and operator for their guide and skill in make me understanding the process involve for Xerox Project production.

And also to my parent and family for give their spirit where help me to complete my project well. Lastly special thanks to my entire friend directly or indirect involve in help to complete my thesis with success.

Wassalam.....

ABSTRACT

Generally the purpose of this research is to review ands explore the basic concepts and fundamentals of six sigma (DMAIC), its benefit, limitation and successful approaches for implementation of using six sigma methodology in manufacturing industry by complete a case study. Flextronics Senai, PLO 1, Malaysia SDN BHD Johore, as a one of electronic manufacturing industry in Malaysia is placed chooses to complete this study. The management give their permission to implement this study by using one of projects i.e. XEROX Project, and the title of this case study is XEROX BGA Defect Reduction. Generally as implementation of Six Sigma.

In this case study, the team implement DMAIC approach as a method in Six Sigma methodology. This approach comprises of steps such as define, measure, analyze, improve, and control. The results of this approach in improving the manufacturing process in Xerox project was significant. The current process targeted to achieve reducing BGA fallout on the soldering defect from 0.69% to very comfortable value. After implementing Six Sigma, result show BGA fallout from 0.69% can be reduce to 0.2%.

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LIST OF SYMBOLS

BGA	:	Ball Grid Array
Cp	:	Process Capability
Cpk	:	Short term standard deviation
CTQ	:	Critical To Quality
DET	:	Detect
DFSS	:	Design For Six Sigma
DPMO	:	Defect per Million Opportunities
ESD	:	Electro Static Discharge
Dp	:	Design parameter
PCB	:	Printed Circuit Board
PCBA	:	Printed Circuit Board Assembly
ME	:	manufacturing Engineer
QA	:	Quality Assurance
FT	:	Failure Test
GB	:	Green Belt
SMT	:	Surface Mount Technology
SOP	:	Standard Operation Procedure
WI	:	Work Instruction
ICT	:	In Circuit Test
FCT	:	Function Circuit Test
MSD	:	Moisture Sensitive Device
FMEA	:	Failure Mode and Effect Analysis
SEV	:	Severe
OCC	:	Occur
I	:	Individual
MR	:	Moving Rate
UCL	:	Upper Control Limit
LCL	:	Lower Control Limit
KPIV	:	Key Process Input Variable
Ho	:	Data is Normally Distributed
Ha	:	Data is Normally Not Distributed
TQM	:	Total Quality Management
JIT	:	Just in Time
SPC	:	Statistical Process Control
GE	:	General Electric
FR	:	Functional Requirement
Dp	:	Design Parameter

CHAPTER 1
INTRODUCTION

1.1 Introduction

Six Sigma is a powerful business strategy that seeks to identify and eliminating defects causes of errors throughout the organization's in manufacturing industry by focusing on outputs that are critical to customers. DMAIC, pronounced (De-May-Ick), refers to a data-driven quality strategy for improving processes, and is an integral part of the company's Six Sigma Quality Initiative. DMAIC is an acronym for five interconnected phases: Define, Measure, Analyze, Improve and Control (Kai Yang & El-Haik, 2003). Both elements will be direct implement to achieve the goal of this study. For this study, we are looking for Six Sigma (DMAIC) as one of another solution for this problem.

1.2 Background

Manufacturing industry is the backbone of any industrialized nation. Its importance is emphasized by fact that, as an economic activity, it comprises approximately 20% to 30% of the value of all goods and services produced. A country's level of manufacturing activities is directly related to its economic health. Generally, the higher the level of manufacturing activity in a country, the higher the standard of living of its people (Kalpakjian & Steven, 2001). In Malaysia Business Forecast Report Magazine (Tan Liat Kiang, 2005) state those manufacturing industries contribute for 30.4% of Malaysia's GDP for final quarter of last year.

However in manufacturing industry, we normally expose by a lot of problem occur during manufacturer, as an example like product defect, lack of quality, product scrap, customer dissatisfaction and wastement. As solution there are a lot of methodology have been practically used in manufacturing industry like Total Quality Management (TQM), Just in Time (JIT), kaizen, Statistical Process Control (SPC), and Lean (Joseph & William, 2004). The problem is how far the effectiveness of that's methodology and is that way the only solution for this problem.

1.2.1 Background of Study

Flextronics Senai, is a leading provider of advanced electronics manufacturing services to OEMs primarily in the telecommunications and networking, consumer electronics and computer industries. The company's strategy is to provide customers with the ability to outsource, on a global basis; a complete product where the companies take responsibility for engineering, supply chain management, assembly, integration, and test and logistics management. The company provides complete product design services, including electrical and mechanical, circuit and layout

Basically in flextronic Senai there was seven project where are running in production line with is 2 Wire, HP CP, Proxim, Xerox, OQO, XM Radio, and Infocus. Each project is having several model and it running base on work order. The critical considerations leading to decisions making for deciding on used Six Sigma are because of their need to be prepared for greater price competition, spend too much time and money for reworking process, see the market opportunities for products with better quality and reliability, aren't satisfied with their current rate of improvements, need a common language and metrics for quality across Flextronics, need to improve their use of data, need to measure process quality, and need to share their best practices across Flextronics.

1.3 Scope

The scope of these studies focus for implementation of Six Sigma methodology by using: Define, Measure, Analyze, Improve, and Control DMAIC methodology for Xerox model in Flextronics Senai, Johore.

1.4 Objectives

The objectives of this study are:

i. To be familiar with manufacturing process and its problem in electronics industry.
ii. To understand the concept of Six sigma methodology in improving quality of product.
iii. To apply the Six Sigma methodology in solving problem of Manufacturing Industry.
iv. To implement DMAIC methodology as Six sigma method to improve yield on the SMT process by reducing BGA defect from 0.69% of Xerox Model.

1.5 Problem Statement

As for the problem statement, the pass fallout reported for Xerox model, Saturn Head Driver from Flex flow, noticed about 0.69% (see Figure 1) is directly related to Ball Grid Array (BGA) soldering issues. The target for implementation Six Sigma to this study is to reduce the BGA fallout on the soldering defect from 0.69% and also to continue improvement the yield on the Surface Mount Technology (SMT) process. See Table 1

Table 1: BGA Fallout (%) for all projects (Flextronic, 2005)

Project	Model	Total Rejected	Total Build	Percentage
2Wire	SHPL1800HW	82	97151	0.08%
Xerox	Saturn Head Driver	73	10569	0.69%
	Saturn Main Board	33	7471	0.44%
Proxim	WRR Digital	5	1100	0.45%
	WAC Digital	1	220	0.45%

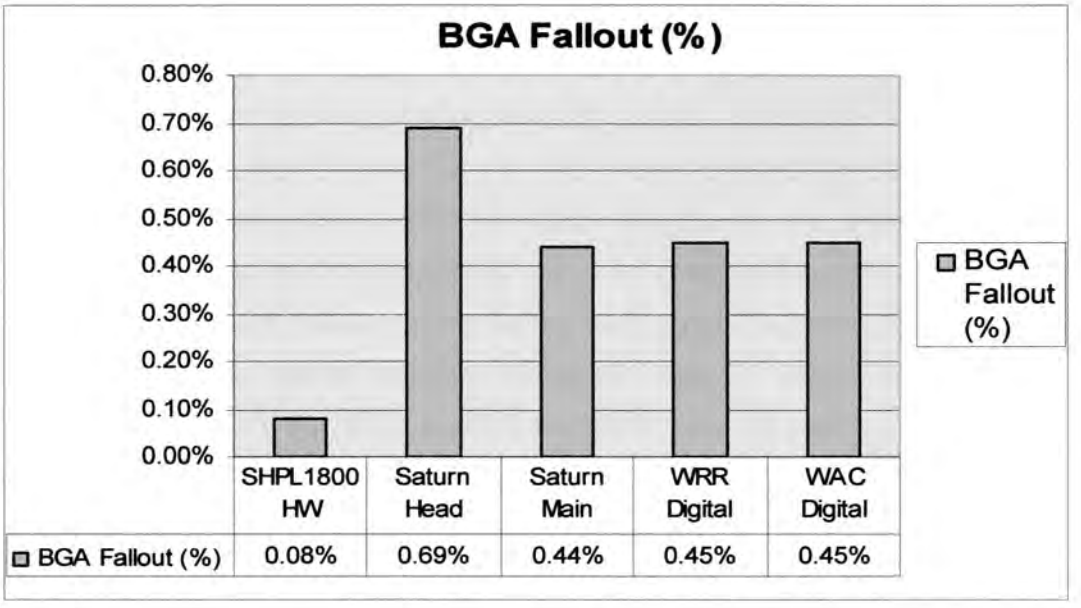

Figure 1: BGA Fallout for Xerox project (Flextronics, 2005)

CHAPTER 2
LITERATURE REVIEW

2.1 Six Sigma definitions and philosophy

At Motorola, Six Sigma has been and still is defined as a quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities. It uses the normal distribution and strong relationships between product nonconformities, or defects, and product yield, reliability, cycle time, inventory, schedule, and so on (Tadikamala, 1994). However, there is some confusion and uncertainty among many people (including statisticians) on how Six Sigma quality translates statistically into 3.4 defects per million (Tadikamala, 1994). In fact, there is a difference in the true value of Six Sigma and Motorola's value of Six Sigma (Billups, 1993). To understand the definition of Six Sigma, it is important to differentiate between these.

The sigma value of a process describes the quality level of that process. A quality level of K sigma exists in a process when the half tolerance of the measured product characteristic is equal to K times the standard deviation of the process:

K * process standard deviation = half tolerance of specification

However, this definition alone does not account for the centering of a process. A process is centered when X = T, where X is the process average or mean and T is the target value, which is typically the midpoint between the customer's upper specification limit (USL) and the lower specification limit (LSL). A process is off

centered when the process average, X, does not equal the target value T. The off centering of a process is measured in standard deviations or sigma.

As **Table 2** (Tadikamala, 1994) shows, the value or number of defects of a process is a function of the sigma value (quality level) of the process (e.g. 6 sigma) and the off centering value of the process (e.g. 0 or 1.5 sigma). The true value of the quality level of a process is the number of defects that occur when the process is centered, when the off-centering value is 0 sigma. In the case of six sigma, there are 0.002 defects per million or 2 defects per billion. O the other hand, ``Motorola's concept of 6 sigma allows a shift in the mean of 1.5 sigma" (Evans, 1993). Therefore Motorola's value of six sigma assumes an allowable shift of 1.5 sigma and thus also shows a defect rate not exceeding 3.4 per million. The value of 3.4 defects per million in a centered process implies a process quality level between 4 and 5 sigma. This is the concept that was introduced and popularized by Motorola and became known as Six Sigma (Anonymous, 1998a).

Depending on whom to be asking, Six Sigma has different meanings and interpretations. ``From the technical viewpoint, it might make sense to talk in terms of process variance; from the managerial or customer viewpoint, the quality standards can be described in terms of defects per million" (Tadikamala, 1994).

Other definitions that have been used include, Six Sigma is a formal methodology for measuring, analyzing, improving and then controlling or ``locking in" processes. This statistical approach reduces the occurrence of defects from a three sigma level or 66,800 defects per million (average for most companies) to a six sigma level ± less than four defects per million (Bolze, 1998) (GE Harris Corporation) (see **Table 3**).

By definition, Six Sigma is a statistical term that refers to 3.4 defects per million opportunities (or 99.99966 percent accuracy), which is as close as anyone is likely to get to perfect. A defect can be anything from a faulty part to an incorrect customer bill (Paul, 1999).

Think of a sigma as a mark on a bell curve that measures standard deviation. Most companies have between 35,000 and 50,000 defects per million operations, or about 3 sigma (Conlin, 1998). Six Sigma equates to 3.4 defects per million opportunities.

Table 2: The number of defectives (part per million) for specified off-centering of the process and quality levels. (Tadikamala, 1994)

	Sigma/quality level						
Off-centering	3 Sigma	3.5 Sigma	4 Sigma	4.5 Sigma	5 Sigma	5.5 Sigma	6 Sigma
0 Sigma	2,700	465	63	6.8	0.57	0.034	0.002
0.25 Sigma	3,577	666	99	12.8	1.02	0.1056	0.0063
0.5 Sigma	6,440	1,382	236	32	3.4	0.71	0.019
0.75 Sigma	12,288	3,011	665	88.5	11	1.02	0.1
1 Sigma	22,288	6,433	1,350	233	32	3.4	0.39
1.25 Sigma	40,111	12,201	3,000	577	88.5	10.7	1
1.5 Sigma	66,803	22,800	6,200	1,350	233	32	3.4
1.75 Sigma	105,601	40,100	12,200	3,000	577	88.4	11
2 Sigma	158,700	66,800	22,800	6,200	1.3	233	32

Six Sigma is for broader, institutional maladies versus kaizen is for fixing small problems in a matter of days says Wayne Hewitt, general manager of global six sigma quality for GE Plastics division. The Japanese concept of kaizen, or continuous improvement, already has been introduced to many US manufacturers (Murphy, 1998).

Six Sigma is a quality initiative that employs statistical measurements to achieve 3.4 defective parts per million ± the virtual elimination of errors (Murphy, 1998).At General Electric, Six Sigma is a measurement. A more illustrative explanation can be

found in a 1997 letter Welch sent to GE stockholders: ``The Six Sigma quality initiative, very briefly, means going from approximately 35,000 defects per million operations, which is average for most companies, including GE, to fewer than four defects per million in every element in every process that this company engages in every day" (General Electric Company) (Hendericks and Kelbaugh, 1998).

Six Sigma, the most recent quality initiative to hit the UK, might very well seem to have the stigma of being the latest in a stream of management fadism. Scott Adams, writer of Dilbert, has referred to quality programs as a way of becoming efficient at the things your company should not be doing. To the uninitiated, it [Six Sigma] seems like another term for total quality management. In fact, it is the Koh-i-Noor diamond, the Rolls Royce, the Veuve Clicquot of quality programs . . . and it comes at a very heavy price (Murdoch, 1998).

Six Sigma, a comprehensive, statistics-based methodology that aims to achieve nothing less than perfection in every single company process and product (Paul, 1999).When used as a metric, Six Sigma technically means having no more than 3.4 defects per million opportunities in any process, product, or service (Anonymous, 1998b).Six Sigma alters the paradigm from fixing defective products to correcting the process so that perfect products are made (Kane, 1998).

Table 3: Six Sigma and defects per million opportunities. (Bolze, 1998)

Sigma	DPMOa
2	308,537
3	660,807
4	6,210
5	283
6	3

Notes: A defects per million opportunities. b Most US businesses operate at the 3 sigma level

2.1.1 Selection of Six Sigma

Today, nearly all companies are facing the harsh realities of a competitive environment. This is no time for evolutionary change. Instead, companies are instituting revolutionary changes meant to have impact within a very short time frame:

> Six Sigma can be a powerful tool for companies that compete on the basis of the quality of their products. However, in markets such as computer technology and retail, where innovation and speed are more important than quality, Six Sigma may not be worth the trouble. Even in companies where quality is a major driver, it's a long haul to realize tangible bottom-line benefits, and some companies put a halt to their Six Sigma projects before reaching that point. So it's not for everyone. For companies where quality rules the day, however, Six Sigma's proponents seem to outweigh its detractors (Paul, 1999).

Why choose to implement Six Sigma even when it is a long haul in both time and dollars spent to realize tangible bottom-line benefits? Some of the key reasons are:

(1) To be responsive to and focused on the customer base:

- We realized early on that just as our customers were instituting changes, we also needed to change some of our processes so that we could be more responsive. Customers now needed solutions faster and were asking us to be quicker, too.
- The goal of the new leader is to focus on the customer and enhance delivery of value (Torode, 1998).
- Sales and marketing VP at GE Aircraft Engines directly attributes the success of the division to the Six Sigma initiative: ``it has helped our salespeople focus on building relationships with our customers [whose demands] for increased value have forced us to place a greater emphasis on speed, quality, and productivity" (Cohen, 1997).

- The concept of agile manufacturing as the best way to anticipate customer needs. ``We need to do what the customer wants before they want it. We needed to look at the future and match customer needs with our core competencies. We [need] to operate in a dynamic systems and change direction fast in response to the environment" said Phil Roether, VP of the systems group and manager for product production processes (Litsikas,1997).

(2) To improve product and service performance:

- The goal of Six Sigma is to improve product and service performance by reducing defects inherent in the processes and materials used to produce them (Torode, 1998) (GE Capital ITS).
- Company executives say they want zero defects from their plants (Murphy, 1998).

(3) To improve financial performance and profitability of business:

- Most manufacturers in the USA operate at about three sigma, churning out 66,000 bad parts for every million produced. These companies lose up to 25 percent of their total revenue due to defects (Murphy. 1998).

- Over the past 15 years, GE has pursued business-performance improvement and corporate profitability using a wide range of programs. In 1995, GE CEO Jack Welch directed the company to undertake Six Sigma as a corporate initiative to ultimately improve net profits and operating margin by eliminating defects. Corporate profitability must be the driver of such an effort. If it doesn't deliver dollars to the bottom line, don't do it (Hendericks and Kelbaugh, 1998).

(4) To be able to quantify its quality programs. The Six Sigma process strives to eliminate those defects by forcing a company to quantify its quality. A database is installed to collect information about every process within a facility. Improvement can then be charted on a factual basis. Implementation of Six Sigma within a

business's processes eliminates ``I think" and ``I feel" from conversations about plant operations (Murphy, 1998).

(5) To be considered as a supplier for a business. Electronics suppliers, especially semiconductor manufacturers, commonly have defect levels of less than 100ppm (parts per million) and some even reach SS level quality. Building a part with a low part per million defect rate allows a supplier to be considered for business, but it has become a dying differentiator (Carbone, 1996).

The aim of Six Sigma is to control all processes at the outset well before they get to the customer (Murdoch, 1998). This is done in a variety of ways by different firms. The following approaches represent some of the philosophical underpinnings, At GE the process measures how products are made and how customers are serviced. Its goal is to ensure that there are no problems with any product or service that GE provides. This is done through quarterly customer surveys and daily manufacturing checks by internal engineers (Cohen, 1997).

Six Sigma teams use extremely rigorous data collection and statistical analysis to ferret out sources of errors and to find ways to eliminate them. The basic approach is to measure performance on an existing process, compare it with a statistically valid ideal and figure out how to eliminate any variation (Paul, 1999) (General Electric Company).

The process, originally used for manufactured goods, is today being applied to all aspects of our business: manufacturing, program execution, product development, new business acquisition, customer service, accounting and more. It starts with a detailed analysis to quantify and measure factors that are critical to our customers' success, and to find ways to remove obstacles (defects) to that success. When the process is working, it results in an entire organization thinking about meeting customer ``critical-to-quality" objectives and eliminating steps that do not add value (Bolze, 1998) (GE Harris Corporation).